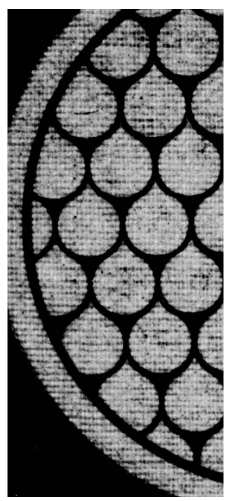
AD-A036 540 CAMP DRESSER AND MCKEE BOSTON MASS F/G 13/2
UPPER TRINITY RIVER BASIN COMPREHENSIVE SEWERAGE PLAN. VOLUME I--ETC(U)
JUL 70

UNCLASSIFIED NL

1 OF 5
AD
A036540



(11) 6 Jul 70 (12) 438 p.

(2)

REPORT TO THE

NORTH CENTRAL TEXAS COUNCIL OF GOVERNMENTS

(6)

UPPER TRINITY RIVER BASIN COMPREHENSIVE SEWERAGE PLAN.

~~COMPLETED JULY~~ 1970

VOLUME I.

The preparation of this material was financed through grants from the Texas Water Quality Board and the Water Quality Office, Environmental Protection Agency.

410073

New
CAMP, DRESSER and & McKEE, Boston, Mass
FORREST AND COTTON, INC.
FREESE, NICHOLS AND ENDRESS

410073

JB

THOMAS R. CAMP, EMERITUS
HERMAN G. DRESSER, EMERITUS

JACK E. McKEE
JOSEPH C. LAWLER
ROLAND S. BURLINGAME
DARRELL A. ROOT
JOSEPH E. HENEY
ROBERT C. MARINI
CHARLES A. PARTHUM
DONALD E. CULLIVAN
WILLIAM C. FREEMAN
PAUL W. PRENDIVILLE

ASSOCIATES
ROBERT H. CULVER
FRANK L. HEANEY
R. ERNEST LEFFEL
FRANK T. SMITH, JR.
NATHANIEL H. CALDER
JOSEPH C. KNOX
R. DENIS C. LLOYD
JAMES ARBUTHNOT
RICHARD H. ESTES
DAVID R. HORSEFIELD
ROBERT F. PELLETIER
ELWOOD C. RICHARDSON
WILLIAM C. TRAQUAIR
RICHARD L. WOODWARD
JOSEPH B. HANLON

ADMINISTRATIVE MANAGER
ROBERT E. JEWETT

CAMP, DRESSER & McKEE

CONSULTING ENGINEERS

WATER RESOURCES
WATER SUPPLY AND TREATMENT
SEWERAGE AND SEWAGE TREATMENT
INDUSTRIAL WASTE TREATMENT
REPORTS DESIGN

DRAINAGE AND FLOOD CONTROL
WATER AND AIR POLLUTION
REFUSE DISPOSAL
RESEARCH AND DEVELOPMENT
SERVICES DURING CONSTRUCTION

July 6, 1970

Mr. W.R. (Bill) Sarsgard, President, and
Members of the Executive Board
North Central Texas Council of Governments
P.O. Box 5888
Arlington, Texas 76011

Upper Trinity River Basin
Comprehensive Sewerage Plan

Gentlemen:

In accordance with the agreement between Camp, Dresser & McKee and the North Central Texas Regional Planning Commission, dated January 15, 1969, we take pleasure in submitting this report. Prepared as a joint effort between Camp, Dresser & McKee; Forrest and Cotton, Inc.; and Freese, Nichols and Endress, this report should serve as a guideline for future planning and development of water pollution control facilities in the region.

This report is presented in two bound volumes. Volume I contains thirteen chapters with text, tables, figures and maps, forming a complete report, and Chapter I contains a general summary of findings, recommendations and conclusions. Volume II contains appendices which include detailed supporting information that will be of use to all member communities, their planners and engineers.

We wish to take this opportunity to thank the very many people who have cooperated with us and given freely of their time and efforts. Among these are Governor Preston Smith and his staff; representatives of the member Cities, Counties, School Districts and Special Purpose Districts of NCTCOG; Messrs. Richard A. Vanderhoof, William C. Galegar, Kenton Kirkpatrick and the staff of the Federal Water Quality Administration - South Central Regional Office; Messrs. Hugh C. Yantis, Jr., Joe P. Teller, Robert G. Fleming, and the staff of the Texas Water Quality Board; Messrs. David H. Brune and Robert N. Tharp of the Trinity River Authority; Mr. Henry J. Graeser and his staff in Dallas and Mr. W. Ralph Hardy and his staff in Fort Worth. We also wish to express our appreciation for the valuable information and assistance received from the Texas Water Development Board, the Texas State Department of Health and the United States Geological Survey.

ONE CENTER PLAZA BOSTON, MASS. 02108 TEL. 617 742-5151 CABLE: CAMDRES

CDM

A special acknowledgement of thanks and appreciation is extended to Mr. William J. Pitstick, Executive Director of NCTCOG, and all the staff members and ad hoc committees of NCTCOG who assisted in the preparation of this report; to the NCTCOG Water Policy Development Committee for its assistance and counsel; and to Mr. James D. Goff, Director of Water Resources, for his outstanding cooperation, assistance and valuable knowledge.

Respectfully submitted,

William B London	S. W. Freese	Charles A Parthum
William B. London, P.E. Forrest and Cotton, Inc. Associate Consultants	Simon W. Freese, P.E. Freese, Nichols and Endress Associate Consultants	Charles A. Parthum, P.E. Camp, Dresser & McKee General Consultants
STATE OF TEXAS WILLIAM B. LONDON 11133 REGISTERED PROFESSIONAL ENGINEER	STATE OF TEXAS S. W. FREESE 1188 REGISTERED PROFESSIONAL ENGINEER	STATE OF TEXAS CHARLES A. PARTHUM 29000 REGISTERED PROFESSIONAL ENGINEER

NORTH CENTRAL TEXAS COUNCIL OF GOVERNMENTS

UPPER TRINITY RIVER BASIN COMPREHENSIVE SEWERAGE PLAN

TABLE OF CONTENTS

Table of Contents (continued)

Table of Contents (continued)
Water Quality Considerations

Table of Contents (continued)
Water Quality Considerations

Table of Contents (continued)
Existing Sewerage Facilities

Table of Contents (continued)
Existing Sewerage Facilities

Table of Contents (continued)
Existing Sewerage Facilities

Table of Contents (continued)
Basis of Cost Estimates

Table of Contents (continued)
Alternative Regional Sewerage Systems

Table of Contents (continued)
Alternative Regional Sewerage Systems

Table of Contents (continued)
Recommended Regional Sewerage Plan

Table of Contents (continued)
Treatment and Disposal of Wastes

Table of Contents (continued)
Treatment and Disposal of Wastes

Table of Contents (continued)
Administration of Recommended Plan

Table of Contents (continued)
Administration of Recommended Plan

Table of Contents (continued)

NORTH CENTRAL TEXAS COUNCIL OF GOVERNMENTS
UPPER TRINITY RIVER
COMPREHENSIVE SEWERAGE PLAN

LIST OF FIGURES

List of Figures (continued)

NORTH CENTRAL TEXAS COUNCIL OF GOVERNMENTS
UPPER TRINITY RIVER
COMPREHENSIVE SEWERAGE PLAN

LIST OF TABLES

List of Tables (continued)

List of Tables (continued)

List of Tables (continued)

CHAPTER I

SUMMARY

DESCRIPTION OF THE STUDY

OBJECTIVE OF THE STUDY

The objective of this study is to prepare a plan which will recommend an area-wide comprehensive sewerage system and program for interceptor and trunk sewers and sewage treatment and disposal facilities in the North Central Texas region and to suggest methods for plan implementation. The output from this study is expected to be of great value not only to the North Central Texas Council of Governments (NCTCOG) but to all member communities in their planning for future development of the area.

Specific watershed recommendations presented in this report are not considered to be absolute because of the generalized nature of the studies. The recommendations are, however, meant to be utilized as a basis of comparison with other possible alternative systems on a watershed basis. Detailed studies for specific localities and projects may indicate that size, location and staging of facilities should depart from the recommendations herein.

CONSULTANT TEAM

In January 1969, the North Central Texas Council of Governments contracted with the consulting engineering firm of Camp, Dresser & McKee of Boston, Massachusetts, to direct and coordinate the work of the consulting team. The consultant team consists of Camp, Dresser & McKee, as the general consultants, and the firms of Forrest and Cotton, Inc. of Dallas, and Freese, Nichols and Endress of Fort Worth as associate consultants. Other special consultants (including legal) were utilized where needed during the preparation of the report.

FINANCING OF STUDY

This report was financed jointly by the Texas Water Quality Board under Contract No. TWQB PG68-1 and the Federal Water Quality Administration (formerly the Federal Water Pollution Control Administration), U.S. Department of the Interior, Project BPG-3-68-12.

AREA OF STUDY

The study encompasses an area of roughly 11,000 square miles located in the North Central part of Texas, including the entire counties of Dallas, Tarrant, Ellis, Denton, Johnson, Collin, Kaufman, Parker, Rockwall and Wise, and those portions of Van Zandt, Henderson, Fannin, Hunt, Grayson, Cooke, Montague, Clay, Jack, Archer and Young tributary to the Upper Trinity River Basin. This area is much larger than several states including Rhode Island and Massachusetts, more populous than Arkansas, Colorado, Nebraska, Oregon and eighteen other states, and includes the

metropolitan area of Dallas and Fort Worth. The area contains about 20% of the population of the State of Texas.

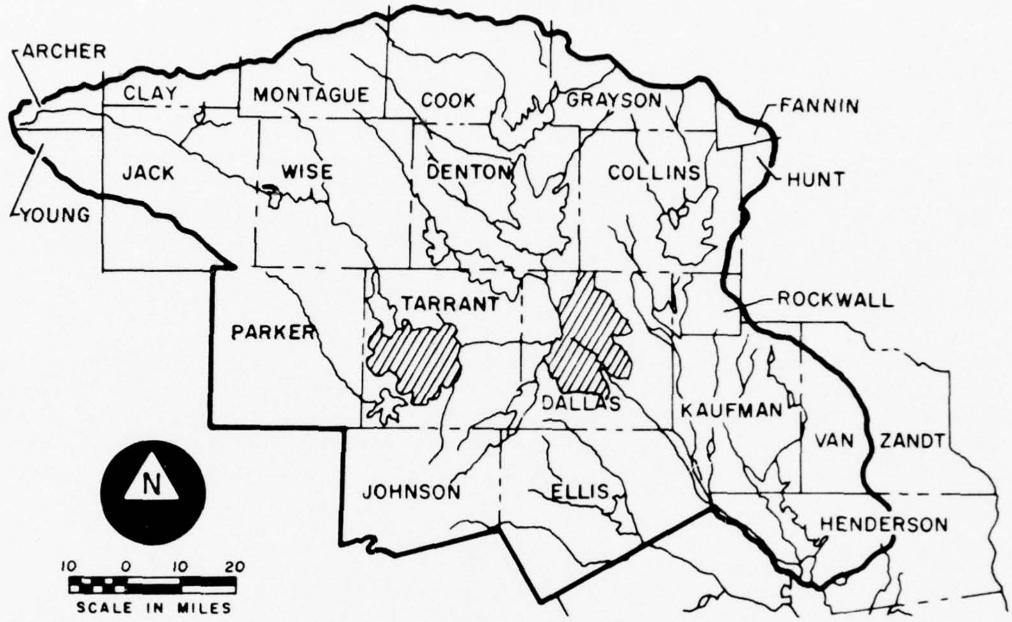


FIG. I-1 MAP OF STUDY AREA

FINDINGS

POPULATION

The population in the study area at the present time is estimated at about 2.7 million, and is expected to almost double in the next twenty years. By the year 2020 the population is expected to reach 7.8 million. Over 80% of the present population is already sewered, and it is expected that this percentage will climb in the next fifty years to about 97% by the year 2020. The area is blessed with sufficient land and sufficient water (at least for the next twenty years or so) to attract and hold new industry and to permit rapid developments and population growth. Beyond 1990 it appears that additional water supplies (from imported or reused water)may be needed to sustain growth. It appears that most of the population (present and future) will reside in the metropolitan areas surrounding Dallas and Fort Worth, and generally lying within Dallas and Tarrant Counties.

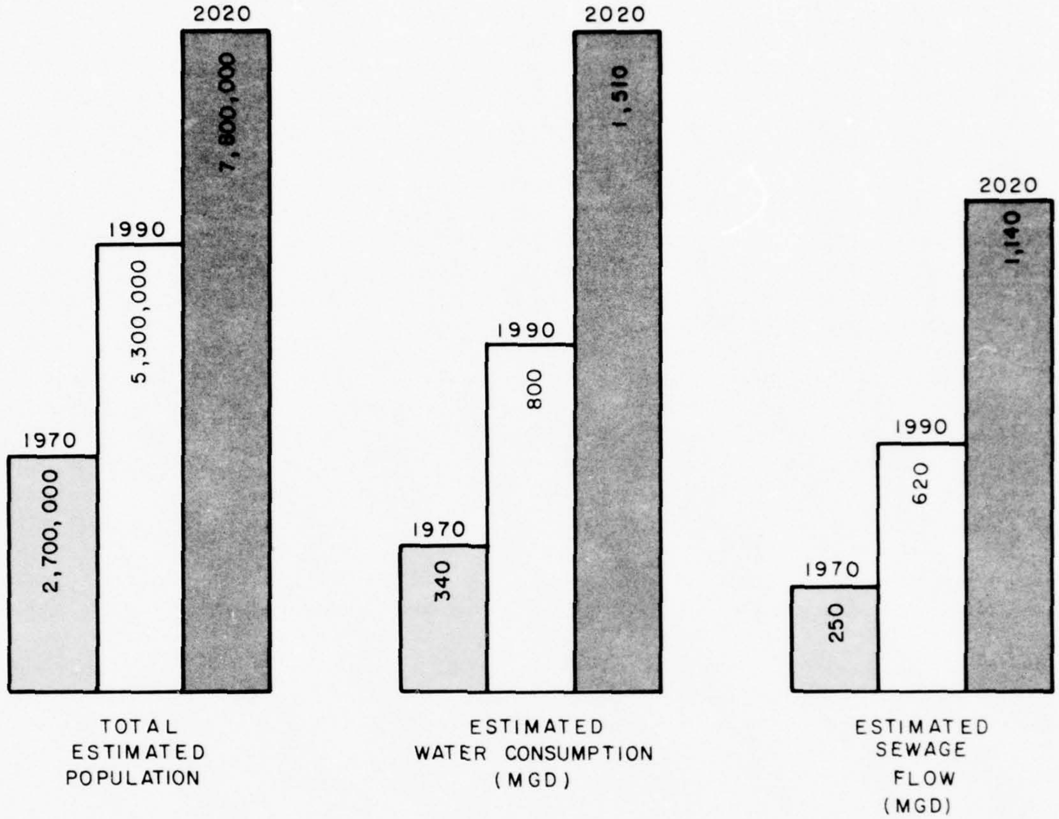


FIG. I-2 PROJECTED POPULATION, WATER CONSUMPTION AND SEWAGE FLOW FOR STUDY AREA

WATER CONSUMPTION AND SEWAGE FLOW

Accompanying this increase in population will be a great increase in water consumption and sewage flow in the study area. Total water consumption is expected to increase from an estimated 340 million gallons per day at the present time to about 1,510 million gallons per day by the year 2020. Most of the water consumed will find its way into municipal sewerage systems and require treatment. From an estimated 250 million gallons a day at the present time, the projected sewage flow to the year 2020 is expected to increase to about 1,140 mgd. On a per capita basis average daily sewage flow is expected to increase from 100 gpcd in 1970 to 150 gpcd in 2020 in the Dallas-Fort Worth metropolitan area.

UPPER TRINITY RIVER WATER QUALITY

Flowing generally from the northwest to the southeast through the North Central Texas region is the Trinity River and its principal tributaries, the West Fork, Elm Fork and East Fork. The flow in the Trinity River is extremely variable - from flood waters in the early spring to almost no natural flow in the dry parts of the year. This extreme variation in flow presents difficulties in attempts to use the Trinity River for recreational and other purposes, and it affects the degree of sewage treatment necessary. Several large water supply reservoirs are located in the basin and their discharges flow into the Trinity River during wet parts of the year. The Trinity River itself flows downstream into the site of the planned (by others) Tennessee Colony Reservoir located at the southern edge of the study area. This reservoir is a projected water supply for a portion of Texas south of our study area. Some reservoirs within the study area receive sewage effluents.

In the dry parts of the year, the flow in the Upper Trinity River and its tributaries consists mostly of the effluent (or discharge) from existing sewage treatment plants, and dissolved oxygen levels are frequently below those necessary to maintain fish life. During the summer months reported biochemical oxygen demand (BOD) and dissolved oxygen levels in many reaches of the Upper Trinity River do not meet the water quality requirements of the TWQB. Extremely high concentrations of nutrients such as phosphates and nitrates are found in the river, and bacteria counts are frequently above acceptable levels particularly during wet weather periods. Reported pesticide concentrations, where they exist at all, are below established limits.

The heavy pollution load in the river results from the discharge of effluents from 132 sewage treatment plants, septic tank discharges, raw sewage discharges from homes, industrial wastewater discharges, leaching from refuse disposal dumps and sanitary landfills, and surface runoff from urban and rural areas. During high river levels, treatment plant sludge lagoons are occasionally flooded and quantities of sludge are carried away by the river.

Thus the Upper Trinity River now poses a potential health hazard, does not satisfy aesthetic considerations and is not suitable for many desired uses.

However, streams and lakes in the Upper Trinity River basin are used at the present time for water supply purposes. In order to protect the public health, to prevent eutrophication (the accelerated aging or deterioration) of lakes and reservoirs and to permit various desired river uses, the sewage from the North Central Texas region must be provided with a very high degree of organic removal combined with nutrient removal and disinfection.

The planned canalization of the Trinity River contains a number of locks and dams, which will tend to retard the natural flow of water. The same very high degree of treatment (advanced treatment) of the area's sewage would be necessary to prevent eutrophication and other undesirable conditions from developing in the river because of this project.

It is considered not feasible to augment the flow of the Upper Trinity River to provide a great flow of water for dilution purposes during low flow periods. An amount of clean augmentation water roughly equivalent to twice the sewage flow from the entire study area (i.e., 1,240 mgd in 1990; 2,280 mgd in 2020) would be required if

conventional secondary treatment only were provided. The time of year during which this water would be needed does not coincide with the timing of available water or that which could be made available (except through importation).

RECOMMENDATIONS

DESCRIPTION OF PROPOSED JOINT FACILITIES

For reasons of economics, centralization of responsibility, and administration of construction, operation and maintenance, six large joint use treatment plants are proposed for sewage treatment in the metropolitan area of Dallas and Fort Worth. Each of these plants exists or is under construction at present. A map of the metropolitan area and the location of the six joint treatment facilities is shown below. A list of the communities and service areas served or proposed to be served by each is as follows (those communities and service areas whose names are preceded by an asterisk (*) are not yet served by the indicated plants):

FORT WORTH VILLAGE CREEK PLANT

Benbrook
Blue Mound
Edgecliff
Everman
Forest Hill
Fort Worth
Haltom City
Hurst (part)
Kennedale
Lake Worth
North Richland Hills (part)
Richland Hills (part)
River Oaks
Saginaw
Sansom Park
Watauga
White Settlement
Arlington (part)
*Azle
*Crowley
*Everman
*Lakeside
*Richland Hills (part)
*Rush Creek Area

TRA CENTRAL

Arlington (part)
Carrollton
Colleyville (part)
Dallas (part)
East Mountain Creek area (part)
Euless
Farmers Branch
Grand Prairie
Grapevine Creek area
Greenview area
Hackberry Creek area
Irving
Kirby Creek area
*Bedford
*Colleyville (part)
*Coppell
*Grapevine
*Hurst (part)
*Keller
*Lewisville
*North Richland Hills (part)
*Regional Airport
*Southlake
*Future development north and west of the proposed Lakeview Reservoir

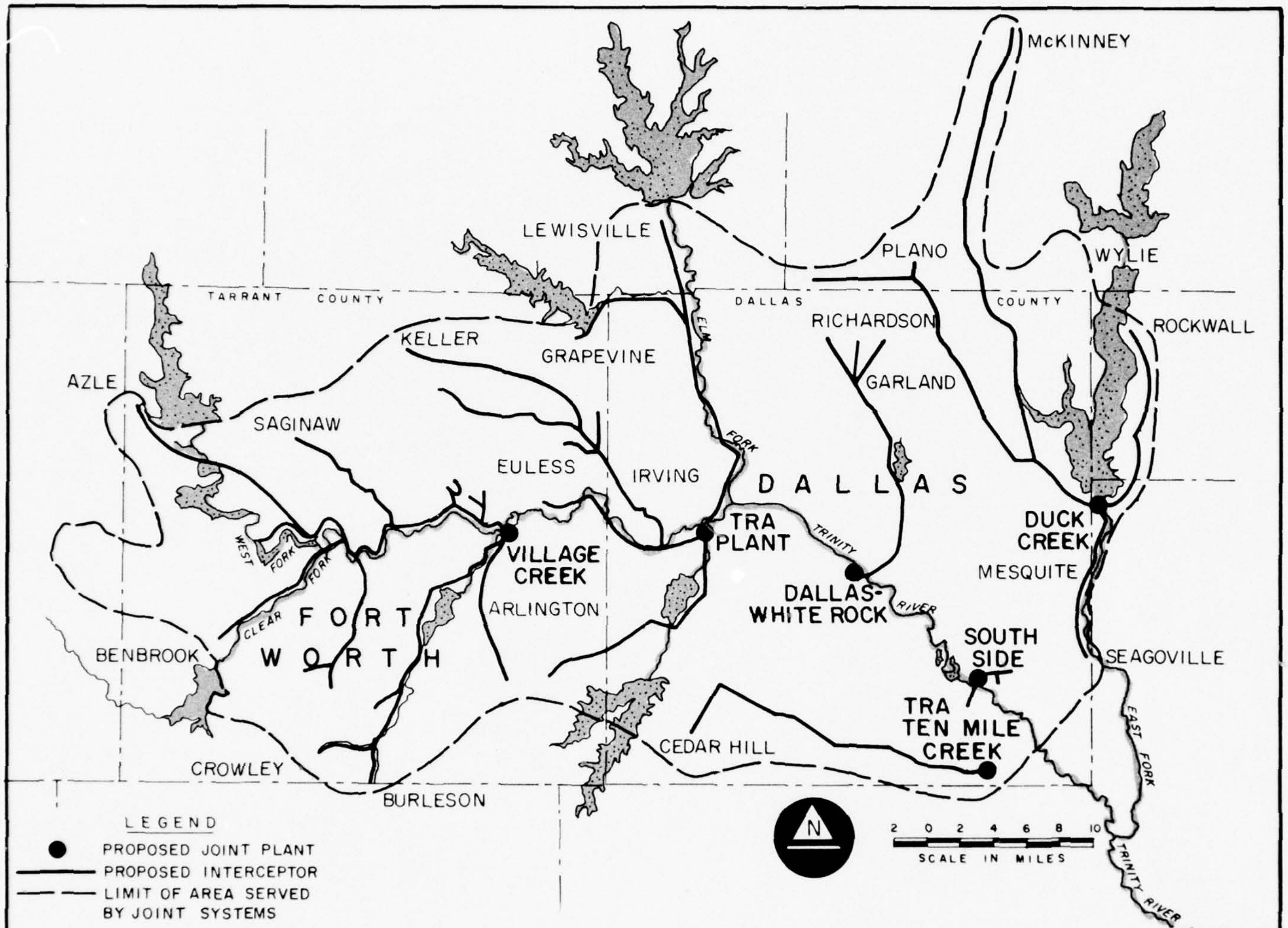


FIG. I-3 RECOMMENDED REGIONAL SEWERAGE SYSTEMS

DALLAS WHITE ROCK PLANT

Dallas (area near the plant and Coombs Creek, Fair Park and White Rock Creek)

*Richardson (Floyd Branch and Cottonwood Creek)

DALLAS SOUTH SIDE PLANT

Elam Creek area
Five Mile Creek area
Prairie Creek area

*Balch Springs
*Hutchins
*Kleberg
*Wilmer

GARLAND-DUCK CREEK PLANT

Garland (part)
Mesquite (part)
Plano (part)
Richardson (part)
Sunnyvale (part)
*Allen
*Garland (part)
*Heath
*Long Creek Area
*McKinney

*Mesquite (part)
*North Mesquite Creek area
*North Seagoville
*Plano (part)
*Richardson (part)
*Rockwall
*Rowlett
*Sachse
*Seagoville (incl Fed. Corr. Instit.)
*Wylie

TRA TEN MILE CREEK PLANT

Cedar Hill
Ferris
Lancaster

De Soto
Woodland Hills
Duncanville

ESTIMATED CONSTRUCTION, OPERATION AND MAINTENANCE COSTS

The expected population and the average sewage flow to the six joint treatment facilities, the estimated construction costs (1970 construction costs) estimated to be needed between now and the year 1990, and the estimated annual average operation and maintenance costs connected with these new facilities between now and the year 1990 are shown on Fig. I-4 and Fig. I-5.

Based on 1970 cost estimates, the people living in the metropolitan area, which may be served by these six joint treatment facilities, can expect to have the cost associated with intercepting sewers and sewage treatment increase about three times over the present cost. A portion of this cost (the construction portion) would, of course, be reduced by the amount of grants in aid available from the Federal and)or State Governments. On an average household basis using 1970 cost estimates, the average annual cost for the recommended joint treatment systems including sewage treatment plants and new interceptor sewers is estimated at about $60 per year, or less than 20¢ per day per family. On the basis of cost per thousand gallons of sewage treated, about 55¢ is indicated, of which an average of about 40¢ is for treatment and about 15¢ is for interceptors.

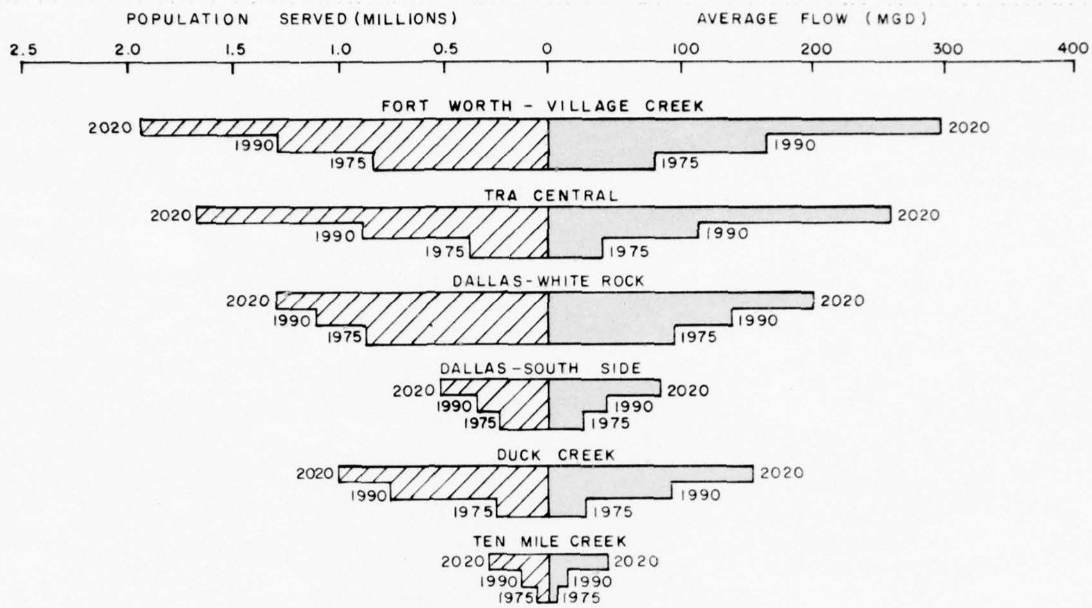


FIG. I-4 PROJECTED POPULATIONS AND FLOWS FOR PROPOSED JOINT PLANTS

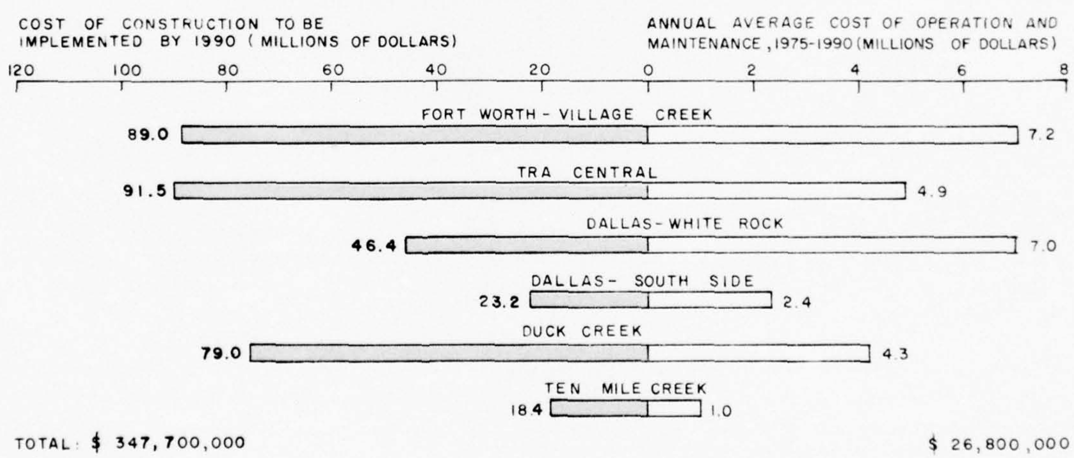


FIG. I-5 PROJECTED COSTS (1970) OF RECOMMENDED JOINT SYSTEMS

The proposed comprehensive sewerage plan will result in the consolidation of sewage treatment plants thus reducing the number from 53 at present to 6 in the metropolitan area.

For those people who live within the study area but outside of the metropolitan area of Dallas-Fort Worth described above, the aggregate construction costs of upgrading sewage treatment facilities between now and 1990, based on 1970 construction cost estimates, is about $50,000,000. The cost per family or per thousand gallons of sewage treated would vary among the individual communities affected.

POLLUTION CONTROL

In addition to inadequate municipal sewage treatment and sludge disposal, the potential for polluting surface waters exists in many other forms. The installation of septic tank systems in areas where soils are inadequate results in failures and overground flow of contaminated waters into brooks, streams and water supply reservoirs. Storm runoff washes contaminants into nearby water sources; sanitary landfills located in areas where groundwater or surface water is able to leach out contaminants and flow directly into streams and water supply reservoirs are another source of pollution. Agriculture, including the fertilizing of farmlands, is suspected during wet weather periods to result in a large volume of phosphates and nutrients being washed into the streams. The uncontrolled grazing and feeding of cattle on watersheds offers a potential for pollution. In certain areas existing water quality standards may not be achieved, even after provision of advanced wastewater treatment, because of pollution from separate surface runoff. Much study would be necessary to determine the feasibility and increased benefits of treating the huge volumes and high flow rates of separate surface runoff involved. Centralization of efforts to control all types of pollution should be the goal of the people in the region.

INFILTRATION

Rainwater infiltration into the sewage collection systems is of a serious magnitude in several of the older and larger systems and results in poor efficiency of treatment plants and raw sewage discharges to streams. The various communities affected should consider the provision of detention and chlorination facilities as needed at critical locations in the systems to prevent raw sewage discharges during periods of high infiltration. Continuing programs of sewerage system maintenance and repair should be carried out to minimize infiltration. Adequate inspection, control, and the use of modern compression type joints in all sewer construction, including building connections, is essential.

WASTEWATER REUSE

As the population and water consumption increase and the surplus supply of water decreases, it will become more and more important to practice wastewater reuse to the fullest extent possible. Non-domestic uses, such as commercial and especially cooling water demands, may be satisfied by wastewater treatment (reclamation) and reuse. Water for domestic uses (after 1990) may have to be supplemented by reclaimed wastewater. The location of suitable industry, including electric power plants, adjacent to sewage treatment plants is recommended.

CONCLUSIONS

IMPLEMENTATION OF THE COMPREHENSIVE SEWERAGE PLAN

The Upper Trinty River Basin Comprehensive Sewerage Plan is a result of a concentrated study over a period of eighteen months. The results of this study clearly indicate that maximum possible cooperation and joint use of sewage collection and treatment facilities will benefit everyone concerned. The Federal Water Quality Administration has the authority to increase federal aid on those projects that are a part of a comprehensive sewerage plan. The Texas Water Quality Board encourages the consolidation of treatment facilities and requires that a new facility be consistent with a regional plan before a discharge permit is issued. The results of this study furnish a framework from which positive action can begin on implementation.

The cost estimates contained in this study should be recognized as general because of the broad scope of the study. A preliminary engineering report defining the service area,intercepting sewer routes and sizes and treatment plant size and process for each of the six recommended joint systems should be prepared as a next logical step. Such a preliminary engineering report would contain refined cost estimates for construction, operation and maintenance of proposed facilities and assist the communities involved to plan their participation in a joint treatment sytem.

Concurrent with these preliminary engineering studies, it is recommended that NCTCOG and all its member communities consider the advantages of a State Grant-In-Aid program for the construction of water pollution abatement facilities. Such a State program (contributing of 25% or more of eligible project costs) would increase the amount of money available to the local communities on eligible projects from a present maximum of 30% (Federal) to about 80% (Federal and State). The Federal Water Quality Act provides increased benefits to states which have their own grant program underway and many states in the country have taken advantage of this. The State of Texas should do likewise.

The TWQB has recently funded NCTCOG to develop an implementation program providing details of the regional organization and its powers. This program is scheduled for completion in March 1971.

PRESENTATION OF THE PLAN

Concerted efforts have been made by the NCTCOG to acquaint all member communities and interested agencies with the Comprehensive Sewerage Plan. Notices were sent to local, State and Federal officials and interested citizens in North Central Texas in advance advising them of the schedule of report presentations. To acquaint as many persons as possible with the contents of the report and to obtain their comments, a number of presentations have been made including those to the following:

Federal Water Quality Administration;

Texas Water Quality Board;

Fort Worth City Council;

Dallas City Council;

Area upstream of Dallas South Side Plant;

Area upstream of Dallas White Rock Plant;

Area upstream of Garland Duck Creek Plant;

Area upstream of Fort Worth-Village Creek Plant;

Area upstream of TRA Ten Mile Creek Plant;

Area upstream of the TRA Central Plant;

Areas outside Dallas and Tarrant Counties.

CHAPTER II

INTRODUCTION

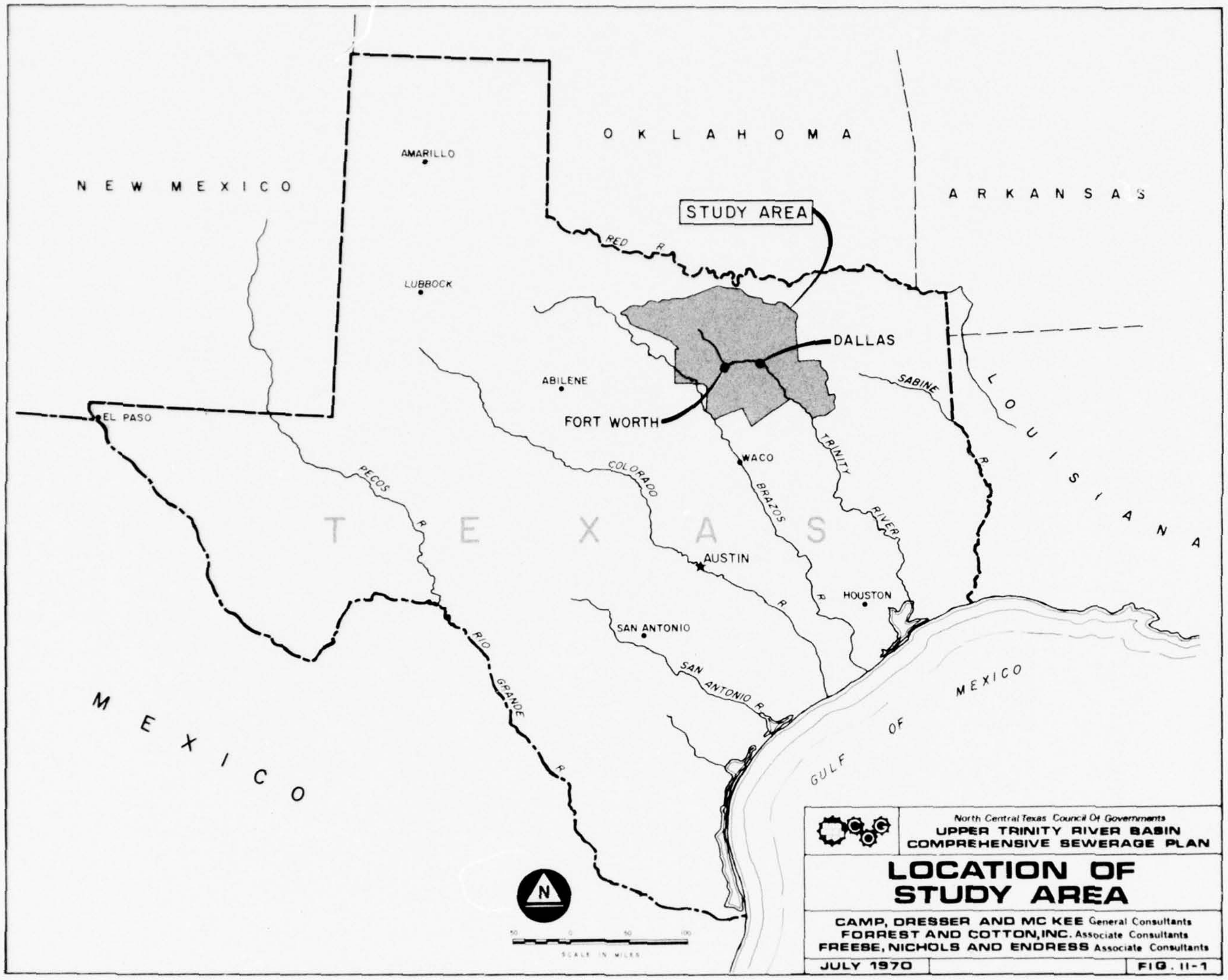
PURPOSE OF COMPREHENSIVE SEWERAGE STUDY

The Upper Trinity River Basin Comprehensive Sewerage Plan has been financed with funds granted by the Federal Water Quality Administration under Section 3 (c) of the Federal Water Pollution Control Act, as amended, and by the Texas Water Quality Board under the provisions of the Texas Water Quality Act of 1967. This report has been prepared by the consulting team of Camp, Dresser & McKee, Boston, Massachusetts, general consultants, and Forrest and Cotton, Inc., Dallas, Texas and Freese, Nichols and Endress, Fort Worth, Texas, associate consultants, under the terms of the contract between Camp, Dresser & McKee and the North Central Texas Regional Planning Commission, effective date January 15,1969.

The purpose of this report is to develop for the North Central Texas Council of Governments (NCTCOG) a comprehensive regional plan and implementation program for sewerage facilities within North Central Texas region (study area) for the foreseeable future (to the year 2020). In this manner water quality requirements may be achieved and the possibility of future degradation of water resources in the North Central Texas region reduced. A map showing the location of the study area within the State of Texas is presented on Fig. II-1. The comprehensive plan forms a basis upon which additional studies of a more detailed nature can be made for proposed sewerage projects within the study area.

The NCTCOG is a voluntary association of local governments represented by locally elected officials in the North Central Texas region. It has become a significant organization for solving many problems in local government such as water pollution control. It was created in 1965 by an Act of the Texas Legislature and as a result of the Federal Demonstration Cities and Metropolitan Development Act of 1966. The latter Act recognized that Federal agencies alone could not provide the necessary communications and coordination required to administer the various Federal programs effectively and efficiently in the metropolitan areas of the nation. The Federal Act required a review and comment procedure on many Federal grant applications at the metropolitan level by an agency responsible for and actively engaged in comprehensive planning throughout the area. That same act made matching Federal funds available to Councils of Government, thereby enabling them to become the regional review agencies. The Texas Attorney General has ruled that Councils of Government also may legally receive Federal grants for water pollution control programs.

This study and report was conducted under the general supervision of Mr. Charles A. Parthum,P.E., Partner-in-Charge, of Camp, Dresser & McKee. Mr. David R. Horsefield, P.E., Associate, was project manager assisted by Dr. Jack E. McKee, Mr. Frank L. Heaney, Dr. Richard L. Woodward, Mr. Max S. Clark and Dr. Jonathan A. French, all of Camp, Dresser & McKee. Mr. Robert R. Steele, P.E., Associate was project engineer (and coordinator of the Texas firms' work) for Forrest and Cotton, Inc., and Mr. Joe B. Mapes, P.E., Associate was project engineer for Freese, Nichols and Endress. Mr. James D. Goff, P.E. was staff project manager for the NCTCOG.


NEW MEXICO
OKLAHOMA
ARKANSAS
LOUISIANA
TEXAS
MEXICO
GULF OF MEXICO
STUDY AREA
DALLAS
FORT WORTH
AMARILLO
LUBBOCK
ABILENE
EL PASO
WACO
AUSTIN
HOUSTON
SAN ANTONIO
RED R
SABINE R
TRINITY RIVER
BRAZOS R
COLORADO R
PECOS R
RIO GRANDE R
SAN ANTONIO R
N
SCALE IN MILES
North Central Texas Council Of Governments
UPPER TRINITY RIVER BASIN
COMPREHENSIVE SEWERAGE PLAN
LOCATION OF
STUDY AREA
CAMP, DRESSER AND MC KEE General Consultants
FORREST AND COTTON, INC. Associate Consultants
FREESE, NICHOLS AND ENDRESS Associate Consultants
JULY 1970
FIG. II-1

Findings, conclusions and recommendations of this study have been discussed with agencies, officials and organizations throughout the study area. Among the agencies with whom discussions have been held are the Federal Water Quality Administration, Texas Water Quality Board, Dallas City Council, and Fort Worth City Council. Discussions have also been held with officials and organizations located within the various watersheds in the study area as described in Chapter V and shown on Fig. V-1 appended to this volume.

SCOPE OF STUDY

In accordance with the contract between Camp, Dresser & McKee and the North Central Texas Regional Planning Commission we have considered the Dallas-Fort Worth metropolitan area as a major utility service area and have considered possibilities for its expansion. In addition, we have investigated and developed sewerage projects for immediate and long-range consideration in all watersheds within the 11,000 sq mi study area. Staging requirements for the various projects have been developed which reflect the urgency of needs for collection, transmission and treatment of wastewaters. Projects have been developed with regard to the economic and technical needs and resources of the North Central Texas region.

This comprehensive study has been conducted in seven phases which included, but were not limited to, the following:

Phase I, Survey and Analysis of Existing Facilities. Refined, updated and evaluated significant inventory data previously obtained from existing sewage treatment plants and existing major trunk sewers in the study area.

Phase II, Survey and Analysis of Existing Water Quality. Collected significant data on streams and reservoirs in the study area, described and evaluated sources of pollution from such sources as municipalities, concentrations of septic tanks, and industries and discussed the effects of storm flows on treatment plant operation and the economics of controlling infiltration and surface runoff.

Phase III, Analysis of Population Projections and Determination of Quantity and Quality of Effluent. Evaluated populations for the years 1970, 1975, 1980, 1990 and 2000 provided by NCTCOG under contract with CONSAD Research Corporation of Pittsburgh, Pennsylvania, projected population estimates to the year 2020, and determined existing and projected per capita sewage flows and pollution loads to permit the development of estimates of total flows and pollution loads in the various watersheds through the year 2020.

Phase IV, Analysis of Significant Waste Treatment Facility Requirements. Estimated sewage flows and pollution loads to existing major sewage treatment plants and evaluated the potential for expanding each such plant to handle anticipated future flows and pollution loads.

Phase V, Conceptual Design of Regional Sewerage and Waste Treatment Plan. Prepared preliminary designs and cost comparisons of alternative feasible plans for the entire study area, with the greatest emphasis on the Dallas - Fort Worth metropolitan area, selected the recommended regional sewerage plan based on the results of this alternative study, and discussed flood control storage and low flow augmentation, the economics of wastewater reclamation and reuse and treatment processes and solid waste disposal as it affects water quality.

Phase VI, Administration of Recommended Plan. Discussed the authority of various existing agencies in water pollution control, the responsibility for plan implementation, available methods for financing recommended projects, the effects of variation of population and land use on the recommended plan and the requirements for long-range sewerage planning.

Phase VII, General Financial Program. Developed a schedule of priorities to be followed in implementing the recommended regional sewerage plan, estimated the cost of the projects by stages and discussed methods of financing, construction maintenance and operation and suggested maintenance and operating procedures.

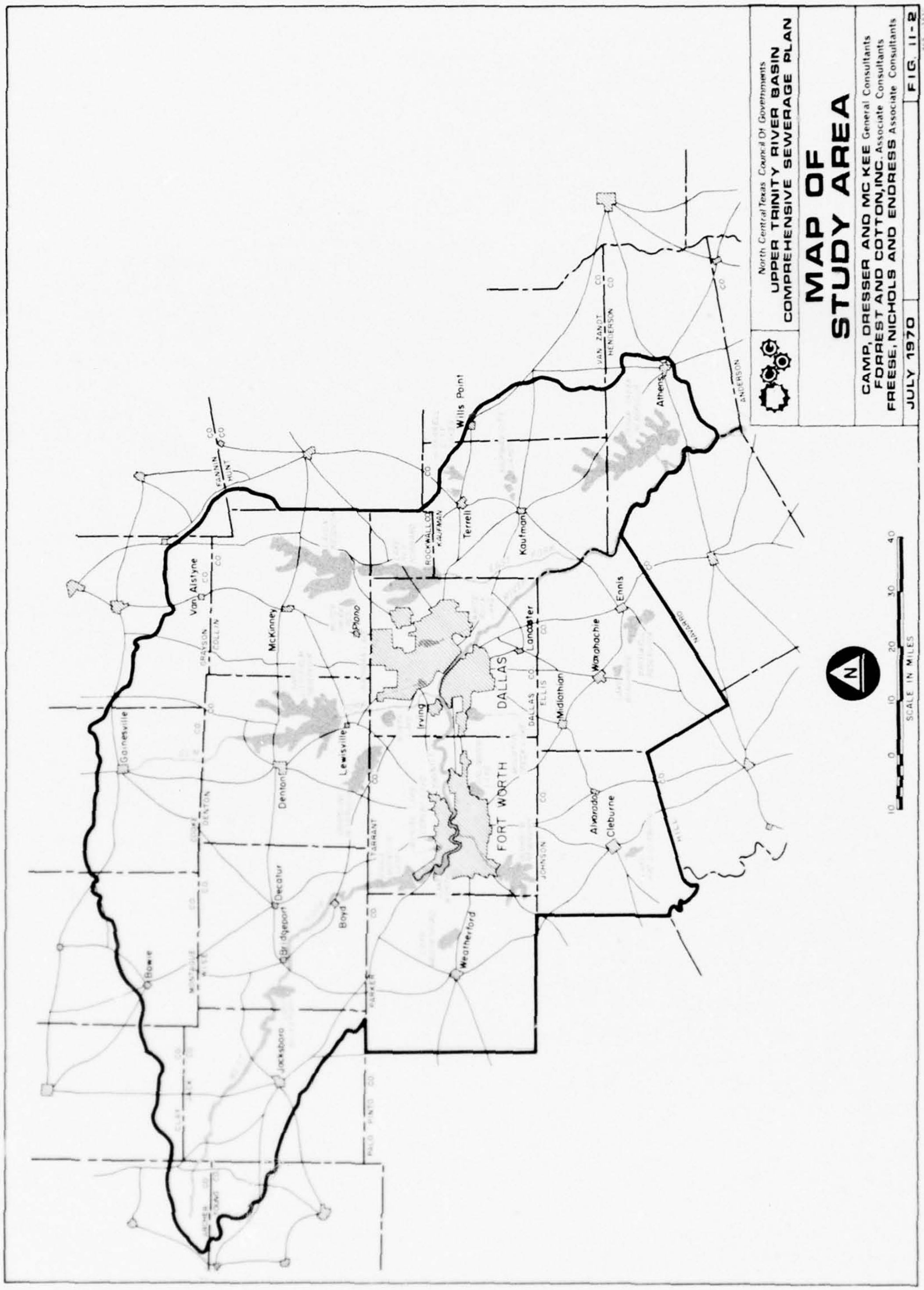
The Upper Trinity River Basin Comprehensive Sewerage Plan is a broad-based study which provides the basis for more detailed sewerage planning of sewerage facilities to accommodate future requirements. Because of its broad scope, no field surveying, subsurface borings, flow gagings, or laboratory analyses were undertaken or were needed to develop the general recommendations in this study. A considerable amount of information previously developed was, however, obtained and utilized.

The North Central Texas region is a dynamically growing area and for this reason, it is difficult to project with great assurance exactly what sewerage needs will be felt through the entire 50 year-period (to 2020). As conditions change and development proceeds, the comprehensive sewerage plan must be updated to assure its relevance to current conditions. It is suggested that this report be updated at five to ten year intervals.

DESCRIPTION OF STUDY AREA

The limits of the study area are defined by county boundaries, watershed divides and by rivers as shown on Fig. II-2. The entire study area covers an area of about 11,000 square miles and includes ten entire counties and parts of 11 others. Most of the study area lies within the Trinity River Basin and makes up about 65 percent of the entire Trinity River Basin drainage area. The area encompassed by the North Central Texas Council of Governments includes ten entire counties: Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise. Counties which lie partly within the study area are Archer, Clay, Cooke, Fannin, Grayson, Henderson, Hunt, Jack, Montague, VanZandt and Young.

In the study area there are over 100 cities, the largest of which are Dallas and Fort Worth located approximately in the center of the study area. The total population of the study area is estimated to be about 2,700,000 at the present time.


North Central Texas Council Of Governments
UPPER TRINITY RIVER BASIN
COMPREHENSIVE SEWERAGE PLAN
MAP OF
STUDY AREA
CAMP, DRESSER AND MC KEE General Consultants
FORREST AND COTTON, INC. Associate Consultants
FREESE, NICHOLS AND ENDRESS Associate Consultants
JULY 1970
FIG. II-2
SCALE IN MILES
10 0 10 20 30 40
Gainesville
Bowie
Jacksboro
Decatur
Bridgeport
Boyd
Denton
Lewisville
McKinney
Van Alstyne
Plano
Weatherford
FORT WORTH
DALLAS
Irving
Lancaster
Midlothian
Waxahachie
Ennis
Alvarado
Cleburne
Terrell
Kaufman
Wills Point
Athens

The principal topographic features of the study area are the manmade lakes located along the Trinity River and its tributary streams. The study area has been described generally as being divided into two topographic zones; the central lowland province and the coastal plain province. The central lowland province is described as that rugged area to the west of Gainesville and Fort Worth, and the coastal plain province is described as the flat rolling terrain to the east of these cities and covering the remaining portion of the study area. General land elevation rises from about 400 ft above sea level at the extreme southeast corner of the study area to about El. 1,250 on the divide in the northwest corner of the Trinity River Basin.

Geologically, the Trinity River Basin has numerous rock outcrop formations ranging in age from the Pennsylvanian to the Pleistocene (glacial) geologic period. Generally, rock formations dip in an easterly and southeasterly direction following roughly the direction of flow of the Trinity River. The southeasterly dip of the strata is greater than the general slope of the land and consequently, the outcrops of successively younger formations are encountered progressing downstream. The top of the rock surface is generally closest to the land surface in the western portion of the study area and lies at a greater depth in the eastern portion of the study area. Most of the land surface is covered with clays of varying types except for some of the larger stream valleys where gravel, silt and sand also occur.

NEED FOR STUDY

The pollution of natural bodies of water by sanitary sewage, agricultural runoff and industrial wastewater is a problem of increasing concern. Prime considerations with regard to pollution are the danger to public health and safety, the befouling of lakes and reservoirs used for water supply, and limitation of the recreational value of lakes, streams and reservoirs. The control of water pollution is essential to the maintenance of an environment conducive to the most enjoyable and beneficial lives both of man and animals.

Contamination of rivers, lakes and streams with organic material, nutrients, disease-producing bacteria and viruses results from the discharge of untreated or inadequately treated wastewater from both urban and rural areas. Floating solids, algae and undesirable aquatic vegetation, oil, scum, turbid or colored waters and odors are physical evidences of pollution and are objectionable.

Many lakes and reservoirs in the North Central Texas region are used for both water supply and recreation purposes. Others are used also for flood control and cooling water purposes. The discharge of polluting substances into these bodies of water threatens their suitability for such purposes. Increasing pollution of streams and lakes will inevitably render them useless ultimately for water-based recreational activities such as fishing, swimming and boating. It is essential that the lakes and streams of the North Central Texas region be fully protected from pollution at the earliest possible time to prevent the degradation of these valuable resources.

The provision of adequate treatment for sewage and industrial wastewaters is essential to eliminate health hazards, prevent the deterioration of lake waters and to provide a more healthful and enjoyable environment. Costs for providing adequate treatment for wastewaters are small when compared with the benefits gained in preserving these bodies of water. The need exists for the most efficient and effective methods for reducing or eliminating the pollution of the water resources of the North Central Texas region.

WATER SUPPLY

Until the drought of the 1950's groundwater was the only source of fresh water in most smaller communities within the study area, and it was generally accepted by these communities that the subsurface aquifers which had supplied them with fresh water for so many years were more than sufficient. However, as the drought progressed and populations increased, the water supplies diminished. Even the water supplies of the larger cities became perilously low. Serious concern gave rise to the organization of committees and the initiation of engineering investigations to develop new water supplies. An example of such a committee is the Dallas Water Survey Committee, formed by the City of Dallas and including all of Dallas County.

A report entitled, "An Inventory of Water Related Systems and Facilities" was prepared by Forrest and Cotton, Inc. and Freese, Nichols and Endress at the direction of the North Central Texas Regional Planning Commission. Water facilities in each of the ten counties in the NCTCOG and in contiguous areas were surveyed and tabulated in that report. Of the 183 distribution systems surveyed, 56 percent of the customers were in Dallas County and 31 percent in Tarrant with only 13 percent in the remaining eight counties in the NCTCOG.

SUBSURFACE WATER SUPPLIES

There are about 400 wells known in the study area that serve water systems of any size. The total average yield of the wells has been estimated at about 35 mgd (million gallons per day) or perhaps 12 percent of the average daily water requirements in the study area. Early wells in the area had piezometric levels of water at or just a few feet below the ground surface, but at present these levels vary from about 800 ft to 1,000 ft below the surface.

The principal water bearing strata in the study area are in the sand formations of the Woodbine, the Paluxy and the Basal Trinity layers in descending order. Recharge of these aquifers is very slow with water movement estimated to be at a rate of only about 60 ft per year. Because of this slow movement and low total yield, artificial recharge by means of injection of treated wastewater does not appear practical on a broad scale.

SURFACE WATER SUPPLIES

During the drought of the 1950's the City of Dallas constructed a pipeline to tap the waters of the Red River for use as a supplemental water supply source. Because of the problems caused by the introduction of this corrosive water into the Dallas distribution system and the subsequent construction of a number of additional surface water supplies, the Red River source is no longer used. Lakes and reservoirs located in and near the study area now supply most of the needs for municipal water. These lakes and reservoirs are listed in Table II-1 and most are shown on Fig. II-2. Most of the lakes and reservoirs in the area are man-made (not natural) and are utilized, as discussed above, for recreational, flood control, water supply or cooling water purposes. The Corps of Engineers has constructed five of the major reservoirs on branches of the Trinity River in the study area: the Lavon, Garza-Little Elm, Grapevine, Benbrook, and Bardwell Reservoirs. Five additional reservoirs are planned within the study area as part of the planned Trinity River improvement program.

TABLE II-1. MAJOR EXISTING RESERVOIRS SERVING THE NCTCOG REGION*

Reservoir	Capacities: Conservation Pool (acre-ft)	Capacities: Flood Pool (acre-ft)	Normal Surface Area (acres)	Safe[(1)] Yield (mgd)
Arlington Lake	35,600	0	2,275	5.8
Bachman Lake	900	0	150	0
Bardwell Reservoir	42,800	79,600	3,570	6.5
Benbrook Lake	72,500	170,350	3,770	8.4
Lake Bridgeport (Enlarged)	400,810	0	13,770	63.0
Cedar Creek Reservoir	608,000	0	33,750	173.5
Cement Lake	0	5,090	270	0
Cleburne Reservoir	18,330	0	1,545	3.2
Eagle Mountain Lake	143,500	0	8,500	-
Garza-Little Elm Reservoir	436,000	525,200	23,280	72.1
Grapevine Reservoir	161,250	238,250	7,380	23.4
Kaufman City Lakes	1,954	3,082	545	-
Lavon Reservoir (Enlarged)	380,000	275,600	21,400	86.6
Marine Lake	3,350	11,600	245	0
Mineral Wells Reservoir	5,005	0	646	0.2
Mountain Creek Lake	25,700	0	2,940	0.4
Muddy Creek Reservoir	7,330	0	885	5.3
North Lake	17,000	0	820	0
Lake Ray Hubbard	483,740	0	24,900	66.9[(2)]
Lake Tawakoni	907,200	0	36,700	206.0[(2)]
Terrell City Lakes	1,500	0	-	1.4
Lake Waxahachie	12,000	0	687	3.2[(2)]
Lake Weatherford	13,100	0	1,280	1.6
White Rock Lake	12,300	0	1,095	0
Lake Worth	31,600	0	3,267	-
TOTALS	3,821,469	1,308,772	193,670	727.5

Notes:

(1) All safe yields determined by the Texas Water Development Board, except as otherwise noted.

(2) Yields determined by engineers for the Trinity River Authority.

*Information in this table from 1968 Forrest and Cotton, Inc., and Freese, Nichols and Endress inventory.

Other major water reservoirs in the study area are Eagle Mountain Lake, Lake Bridgeport, Cedar Creek Lake and Lake Ray Hubbard. The Tawakoni Reservoir, although in the Sabine River Watershed and owned by the Sabine River Authority, supplies water to the City of Dallas. Cedar Creek Lake will supply the City of Fort Worth and Tarrant County when pumping and force main facilities are completed (expected to be in operation by January, 1973). There are also municipal lakes supplying the Cities of Weatherford, Cleburne, Arlington, Waxahachie, Terrell and Kaufman.

The safe yield of the 25 major existing surface water supplies serving the North Central Texas region is estimated to be almost 730 mgd, including 173 mgd from Cedar Creek Lake.

SUMMARY

In 1967, the average daily water consumption in the study area was estimated to be about 268 mgd, and the total water supply presently developed or being developed, including both surface and groundwater supplies, is estimated to be about 765 mgd. Thus, it appears that total water supplies for the study area are adequate at the present time even for peak demand periods. However, in order for the 765 mgd yield to serve all points where it is required in the study area a greater capacity for intra-regional transfer of water would be required than now exists. Projections of water requirements made for this study and also in the Texas Water Plan indicate that the future water needs(beyond about 1990) of the North Central Texas region cannot be met entirely from sources within the area unless extensive reuse of water is made. That Water Plan proposes that water be imported into the region on an interstate or on an inter-basin transfer basis.

OTHER ENGINEERING STUDIES

Many investigations and engineering studies have been made by Federal, State and local governmental agencies and private consultants that have included all or parts of the study area. These reports have been reviewed and evaluated to determine their usefulness and relevance to this study, and they are all listed in the bibliography (Appendix I). Of particular value to this study have been sewerage reports prepared for the Cities of Dallas, Fort Worth, Grand Prairie, Garland, Arlington, and the Trinity River Authority. Many other engineering reports, construction plans and planning reports for cities, counties and agencies within the study area have been reviewed to assist in the development of alternative plans for principal plans for principal trunk sewers and treatment facilities. References have been made to particular studies as they apply to various sections of this report wherever such references appeared appropriate.

CURRENT PROJECTS

Projects and studies recently completed or currently under way in the study area, which have an effect on the comprehensive sewerage plan, include those described below.

Basic Economic and Demographic Study. The CONSAD Research Corporation prepared for NCTCOG an economic and demographic study of the NCTCOG area in which small-area forecasts were made of residential and employment population through the year 2000. A mathematical model of population was prepared and calibrated, and a computer program was developed to generate population projections.

Airport-Related Studies. The NCTCOG is conducting studies related to the effect of the Dallas-Fort Worth Regional Airport on economic growth and urbanization of the area in its vicinity. These studies include compatible land use, airport economic impact analyses, transportation coordination studies, and a cooperative program of planning for airport impact. The Regional Science Research Institute has prepared for the NCTCOG a forecast of the impact of the Regional Airport on nearby cities, in terms of population, employment, and government services required.

Polymers for Sewer Flow Control. The City of Dallas is currently investigating the possible use of polymers in pipelines to reduce energy loss due to friction, thereby increasing the carrying capacity of a pipe of given diameter and slope. The study has been undertaken by the Research Division of the Western Company of Richardson, Texas for the City of Dallas with the support of an FWQA grant and is expected to be completed in 1972.

Infiltration Studies. The Texas Water Quality Board is studying methods and economics of controlling the infiltration of surface and groundwater into sanitary sewers. Design and construction practices for new construction and remedies for existing systems are being studied.

Sewage Treatment Plan Effluent Chlorination Study. An 18-month joint study by Fort Worth and Dallas is presently in progress to determine the effects on the river of chlorination of sewage effluent at municipal treatment plants. The study is being conducted by North Texas State University using the effiuent from the Dallas -White Rock Sewage Treatment Plant.

Wastewater Reclamation Pilot Plant. The City of Dallas has established a 1 mgd wastewater reclamation pilot plant on land adjacent to the White Rock Sewage Treatment Plant. The pilot plant has been built as part of the Dallas Water Reclamation Research Center, designed to provide basic knowledge about advanced wastewater treatment processes. Objectives are to improve the quality of treated wastewater discharged to the Trinity River and to condition the wastewater for reclamation and reuse, initially for industrial use and later as a possible raw water supplement.

Stormwater Treatment Plant. The City of Dallas, with support of a FWQA Grant, is constructing a plant to demonstrate new and improved methods for the treatment of stormwater flows, utilizing coagulants and waste lime from a water treatment plant. An evaluation will be made as to the economics of construction of stormwater treatment facilities versus the alternative of providing additional sewer and conventional treatment capacity.

Trinity River Authority Monitoring Study. The TRA, under contract with the NCTCOG, is conducting an investigation of parameters for measuring the water quality in the Upper Trinity River, including evaluation of existing channel characteristics, and developing requirements for water quality monitoring stations.

Additional studies now under way:

1. A regional transportation study by consultants to the NCTCOG and the Cities of Dallas and Fort Worth which are jointly engaged by the U.S. Department of Transportation to investigate all types of transportation in the metropolitan areas.

2. A Trinity River environmental enhancement study which the Overview Corporation is conducting for the City of Fort Worth.

3. A recreation facilities study being conducted by North Texas State University under an FWQA grant to plan such facilities along the Trinity River in relation to the planned canalization project.

4. A nutrient removal study being conducted by the City of Richardson under an FWQA grant.

5. A study of chlorination of effluent from oxidation ponds being conducted by the Texas State Department of Health at the Ennis Sewage Treatment Plant.

PENDING PROJECTS

Financial Policy Plan. The NCTCOG plans to conduct an investigation as necessary to determine detailed financial and plan implementation requirements of the Upper Trinity River Basin Comprehensive Sewerage Study.

Water Quality Management Study. The Trinity River Authority, in conjunction with Tarrant County Water Control and Improvement District No. 1, has made application to FWQA and TWQB for planning grants to conduct a water quality management study for the entire Trinity River Basin. The study would require about three years, and the majority of the work would be conducted in the reach of the Trinity River lying between the lower limits of the NCTCOG study and the upper limits of the Galveston Bay study areas. It is intended that the results of the COG study and the Galveston Bay study be incorporated with the proposed study, with the result being a water quality management plan for the entire Trinity River Basin.

CHAPTER III

WATER QUALITY CONSIDERATIONS

GENERAL

The development and implementation of a comprehensive sewerage system for North Central Texas requires the full consideration of existing water quality, sources of pollution, and water quality objectives to be obtained. Briefly stated, a comprehensive water pollution abatement program for the area must aim for two objectives:

1. Protect lakes and reservoirs, used for water supply and recreation, from contamination and eutrophication.

2. Enhance the water quality of the Upper Trinity River and its tributaries to permit its optimum use.

Each objective recognizes both public health and aesthetic values. In addition discussion of water quality in the Trinity River must consider the effect of the locks and dams planned for construction as part of the canalization project.

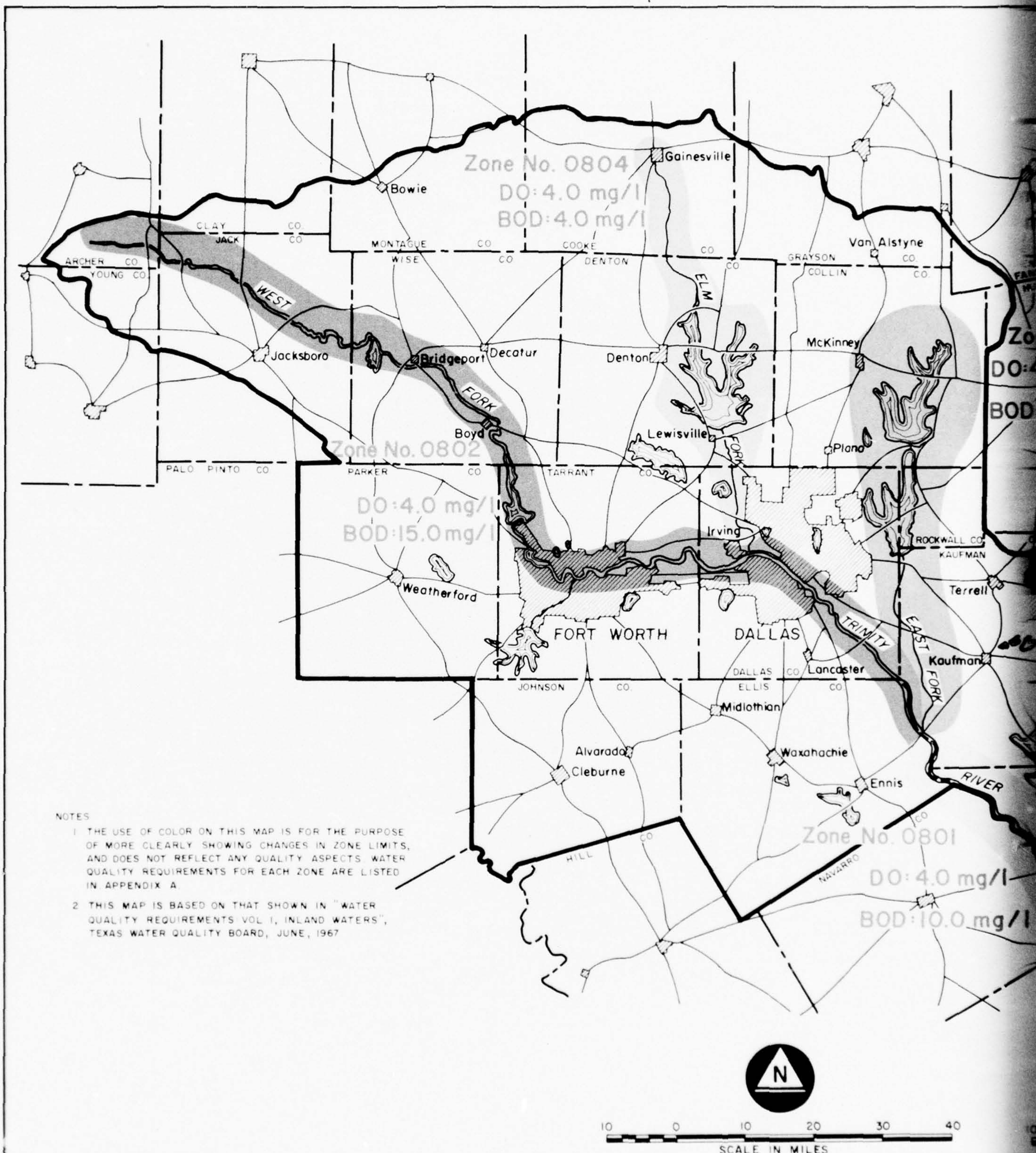
TEXAS WATER QUALITY REQUIREMENTS

The Texas Water Quality Act, as amended, (S.B. 147, 1969) states: "It is the policy of this state and the purpose of this Act to maintain the quality of the water in the state consistent with the public health and enjoyment, the propagation and protection of terrestrial and aquatic life, the operation of existing industries, and the economic development of the state; to encourage and promote the development and use of regional and area-wide waste collection, treatment, and disposal systems to serve the waste disposal needs of the citizens of the state; and to require the use of all reasonable methods to implement this policy."

In accordance with this Act the Texas Water Quality Board has established and published water quality standards for all waters of the State. A copy of the General Statement and specific requirements for water quality zones in the Trinity River Basin are presented in Appendix A. A plan showing the several water quality zones in the Upper Trinity River Basin is presented as Fig. III-1. These requirements were approved by the Federal Water Quality Administration (FWQA), formerly the Federal Water Pollution Control Administration, without exceptions, in January 1968. These requirements include limits of various pollution characteristics to be permitted in the river, suitable uses for the water and known uses.

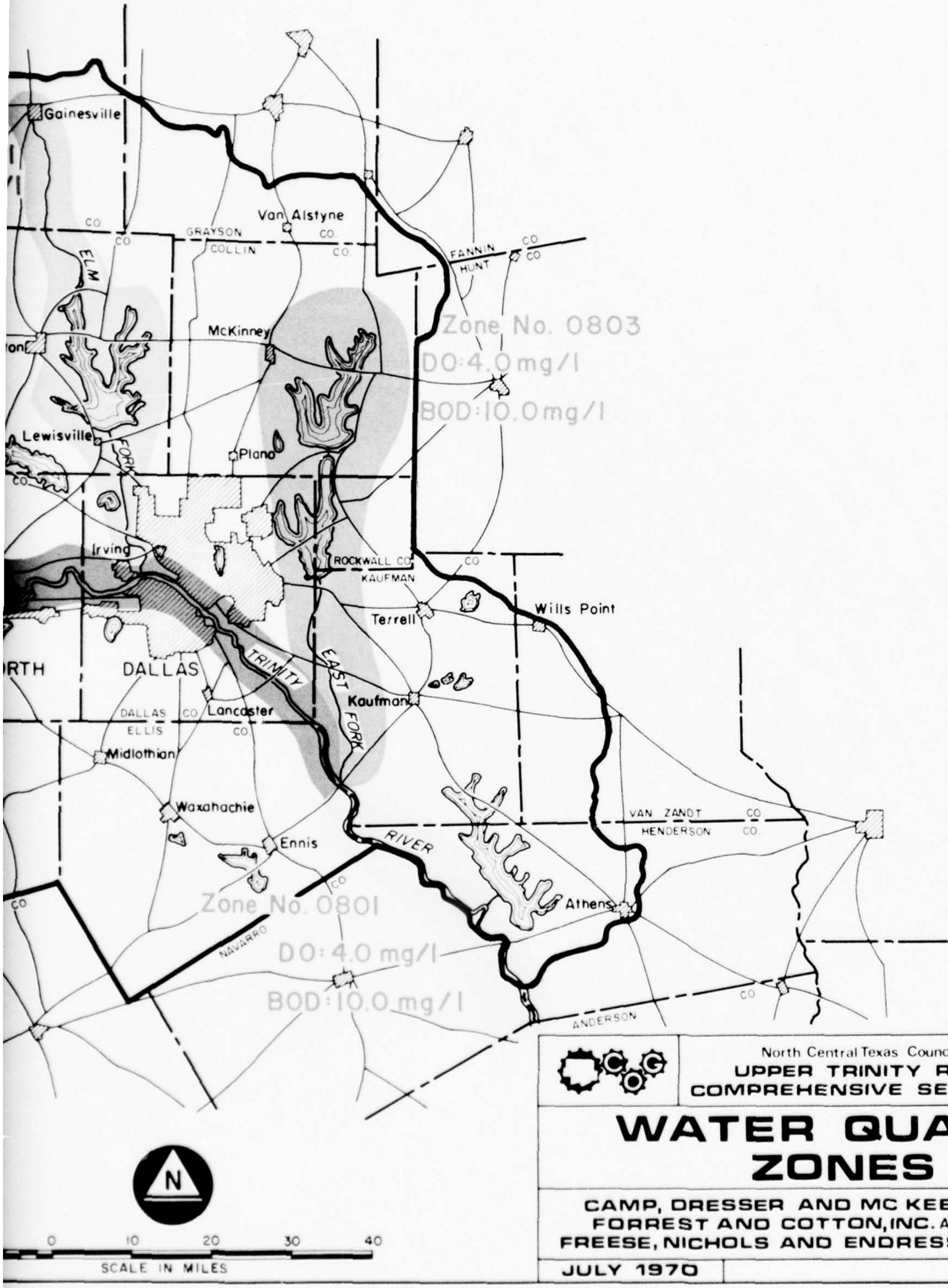
Furthermore, it is the policy of the State to require primary and secondary treatment and disinfection (except for oxidation pond effluents) at all treatment facilities serving the general public. Such treatment is considered to be the minimum required, and in addition, a permit system has been established by the Board which limits the quantity, character and quality of the waste that may be discharged into waters of the State. The Board encourages the consolidation of sewage treatment facilities where feasible.

Construction and operation of the sewage interception and treatment facilities and implementation of the policies recommended herein will help to insure that the surface waters within the North Central Texas region will meet the requirements of the Texas Water Quality Act.



NOTES

1. THE USE OF COLOR ON THIS MAP IS FOR THE PURPOSE OF MORE CLEARLY SHOWING CHANGES IN ZONE LIMITS, AND DOES NOT REFLECT ANY QUALITY ASPECTS. WATER QUALITY REQUIREMENTS FOR EACH ZONE ARE LISTED IN APPENDIX A.
2. THIS MAP IS BASED ON THAT SHOWN IN "WATER QUALITY REQUIREMENTS VOL. I, INLAND WATERS", TEXAS WATER QUALITY BOARD, JUNE, 1967.



North Central Texas Council Of Governments

UPPER TRINITY RIVER BASIN
COMPREHENSIVE SEWERAGE PLAN

WATER QUALITY ZONES

CAMP, DRESSER AND MC KEE General Consultants
FORREST AND COTTON, INC. Associate Consultants
FREESE, NICHOLS AND ENDRESS Associate Consultants

JULY 1970

FIG. III-1

EXISTING WATER QUALITY

The quality of existing surface waters in the North Central Texas region is extremely variable depending on location and climatological conditions. This is due in large part to the fact that much of the region is lightly populated whereas the Dallas-Fort Worth metropolitan area and a few other smaller cities have relatively high concentrations of population and industry. In addition, weather conditions throughout the region vary from extended drought periods to severe tropical type rainstorms.

A fully definitive description of water quality in the study area would require a comprehensive program of water quality monitoring including sampling and analysis. Such a program is currently contemplated by the Trinity River Authority. The discussion herein is based on information obtained from the following agencies:

1. Texas State Department of Health (TSDH)
2. Texas Water Quality Board (TWQB)
3. Texas Water Development Board (TWDB)
4. United States Geological Survey (USGS)
5. The City of Dallas Water Utilities Department
6. The City of Fort Worth Water and Sewer Department

A schematic diagram of water quality is presented on Fig. III-2. This diagram shows the locations of water quality sampling stations, major municipal sewage treatment plants and significant industrial wastewaters sources. Locations are shown by main stem river mile to assist in future oxygen sag analyses.

PREVIOUS INVESTIGATIONS

The data from the TSDH covers a period from 1958 to 1962 and contains a large number of measurements of chloride, sulfate, total solids, dissolved oxygen (D.O.) and BOD. These data have been converted into data bars and are shown on Fig. III-3, III-4, and III-5. They provide a visual indication of the ranges within which the quality of waters in the Trinity River varies. The governing water quality conditions generally are those which occur during low flow periods with accompanying high temperatures.

The objective of that TSDH water quality monitoring program was to provide a general profile of water quality throughout the State. The sampling method used consisted of grab samples taken by State game wardens and shipped, unrefrigerated, by Railway Express or by motor freight. Because of the unrefrigerated nature of the samples, the dissolved oxygen and BOD determinations are not considered fully reliable for comparison with State water quality standards.

In July 1960 the TSDH Division of Water Pollution Control prepared a report entitled "Upper Trinity River Sewage and Industrial Waste Survey." For that report water quality samples were obtained at bi-monthly intervals at 33 sampling points. Results obtained from the samples collected at these "base line" stations indicated that the water in the Trinity River was of generally poor organic quality. Conclusions of that report were as follows:

1. The poor organic quality is a result of inadequate collection and treatment of sewage and industrial wastes, coincident with restricted flow characteristics of the Trinity River.

2. Some municipalities in the survey area, which obtain their water from streams and impoundments are, in fact, using the diluted sewage effluents of upstream cities.

3. Beginning at the confluence of Marine Creek, with the West Fork Trinity River, in Fort Worth, and extending downstream to a point near Rosser, in Kaufman County, the Trinity River is devoid of oxygen and is unable to accomplish self-stabilization. Oxidation of organic matter is retarded and septic conditions and offensive odors are usually present. The water is turbid and discolored. Sludge banks may be observed at numerous locations. There is insufficient oxygen for fish life to propagate.

4. Floating and suspended matter was observed in the Trinity River. Psychoda larvae were found in the waters of the Trinity River on numerous occasions. During high stages of the river, large quantities of raw sewage are discharged from the plants that are operating at, or above, design capacity. This raw sewage increases the BOD of the water and contributes to offensive and unsightly sludge banks when the river subsides.

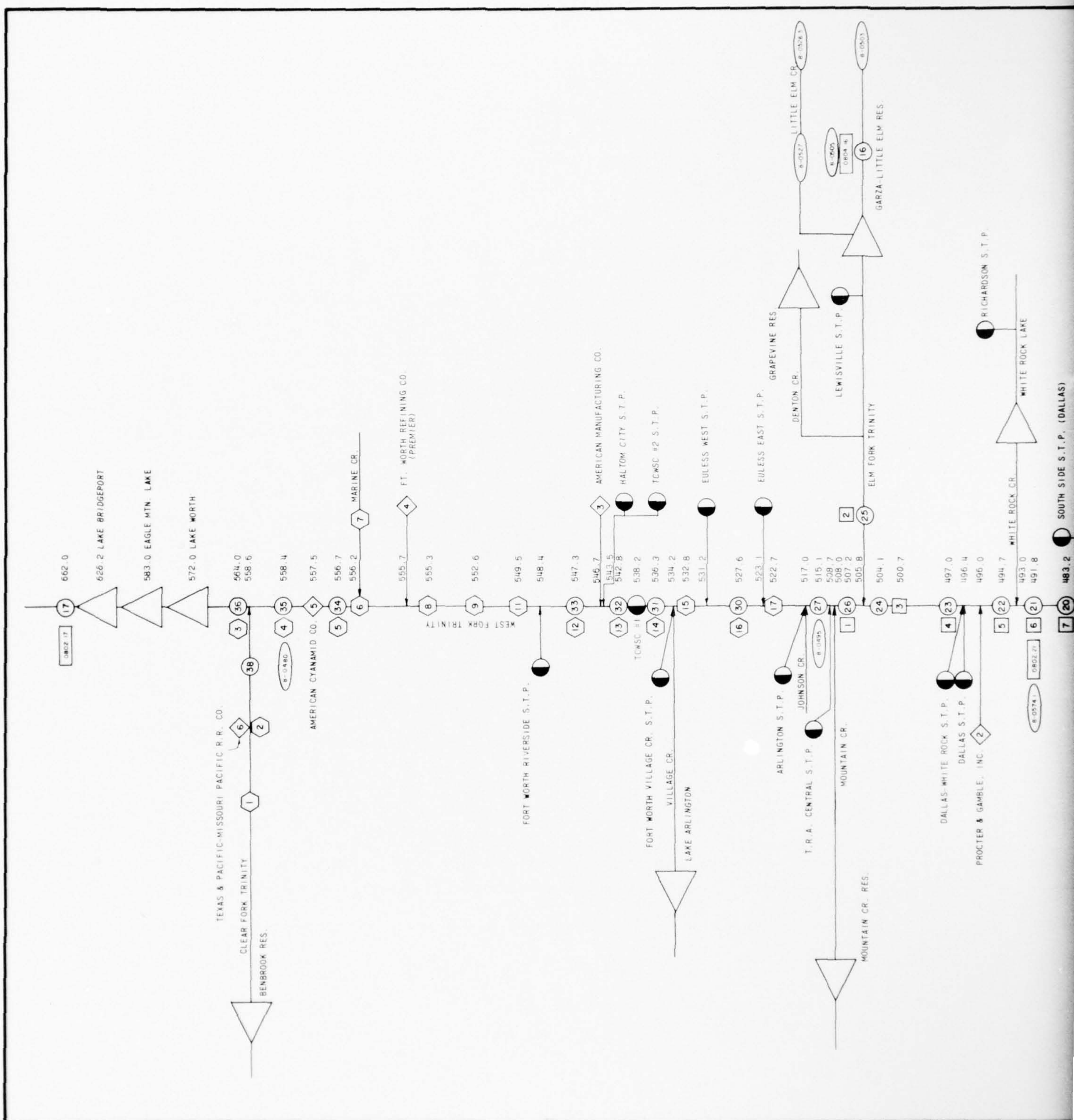
The 1960 report made the following recommendations:

1. To abate the pollution of the Trinity River, all governing bodies or industries that use treatment plants as a method of disposal of wastes should provide sufficient facilities for adequate and complete treatment of wastes.

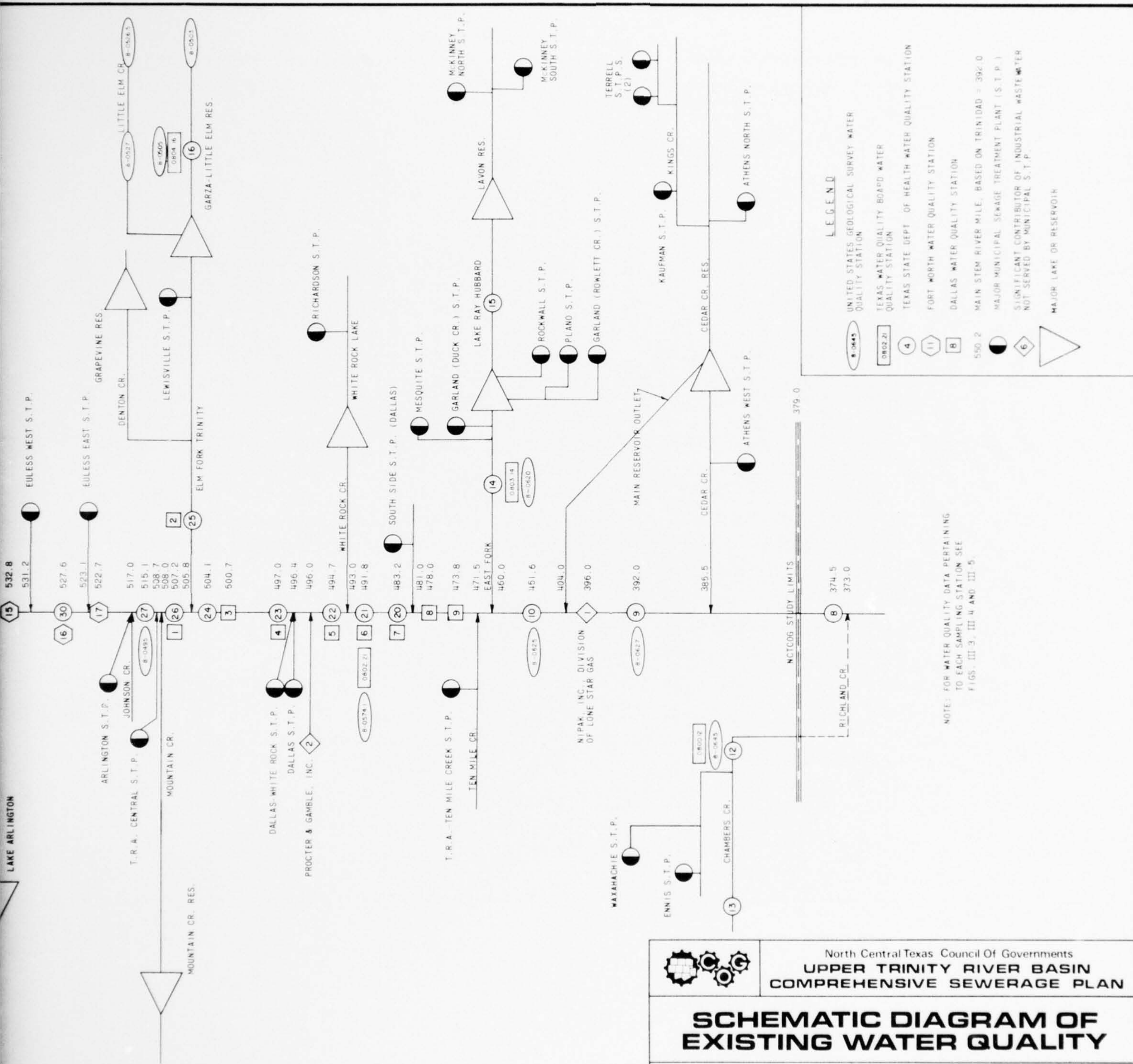
2. A base flow should be maintained in the Trinity River to obtain good water quality conditions. (Estimates made of low flow augmentation requirements are discussed in Chapter X.)

PRESENT CONDITIONS

Present water quality conditions in the Trinity River are discussed below for each of the four water quality zones as shown on Fig. III-1. Recent analyses of samples for D.O., BOD, nitrate and phosphate collected at various selected sampling stations are presented in Table III-1. The analyses shown are considered to be representative of the conditions occurring in the river during critical summer periods for the parameters shown. Plots considered typical of the analyses during such periods for dissolved oxygen and BOD are presented on Fig. III-6, and are compared with maximum allowable annual average BOD concentrations and minimum allowable D.O. concentrations. It is recognized that allowable BOD is expressed in terms of an annual average and that stream conditions on the average may satisfy this requirement. However, the annual average measurement is not considered meaningful for critical summer conditions. It should further be noted that for low flow augmentation studies discussed in Chapter X and Appendix G D.O. requirements and not BOD requirements govern augmentation needs.



WEST FORK TRINITY
662.0
626.2 LAKE BRIDGEPORT
583.0 EAGLE MTN. LAKE
572.0 LAKE WORTH
564.0
558.6
558.4
557.5
556.7
556.2
MARINE CR.
555.7
FT. WORTH REFINING CO. (PREMIER)
555.3
552.6
549.5
548.4
547.3
545.7
543.5
542.8
538.2
536.3
534.2
532.8
531.2
527.6
523.1
522.7
517.0
515.1
508.7
508.0
507.2
505.8
504.1
500.7
497.0
496.4
496.0
494.7
493.0
491.8
483.2
AMERICAN MANUFACTURING CO.
HALTOM CITY S.T.P.
TCWSC #2 S.T.P.
EULESS WEST S.T.P.
EULESS EAST S.T.P.
GRAPEVINE RES.
DENTON CR.
LEWISVILLE S.T.P.
ELM FORK TRINITY
LITTLE ELM CR.
GARZA-LITTLE ELM RES.
RICHARDSON S.T.P.
WHITE ROCK LAKE
WHITE ROCK CR.
SOUTH SIDE S.T.P. (DALLAS)
TEXAS & PACIFIC-MISSOURI PACIFIC R.R. CO.
CLEAR FORK TRINITY
BENBROOK RES.
AMERICAN CYANAMID CO.
FORT WORTH RIVERSIDE S.T.P.
TCWSC #1
FORT WORTH VILLAGE CR. S.T.P.
VILLAGE CR.
LAKE ARLINGTON
ARLINGTON S.T.P.
JOHNSON CR.
T.R.A. CENTRAL S.T.P.
MOUNTAIN CR.
MOUNTAIN CR. RES.
DALLAS WHITE ROCK S.T.P.
DALLAS S.T.P.
PROCTER & GAMBLE, INC.

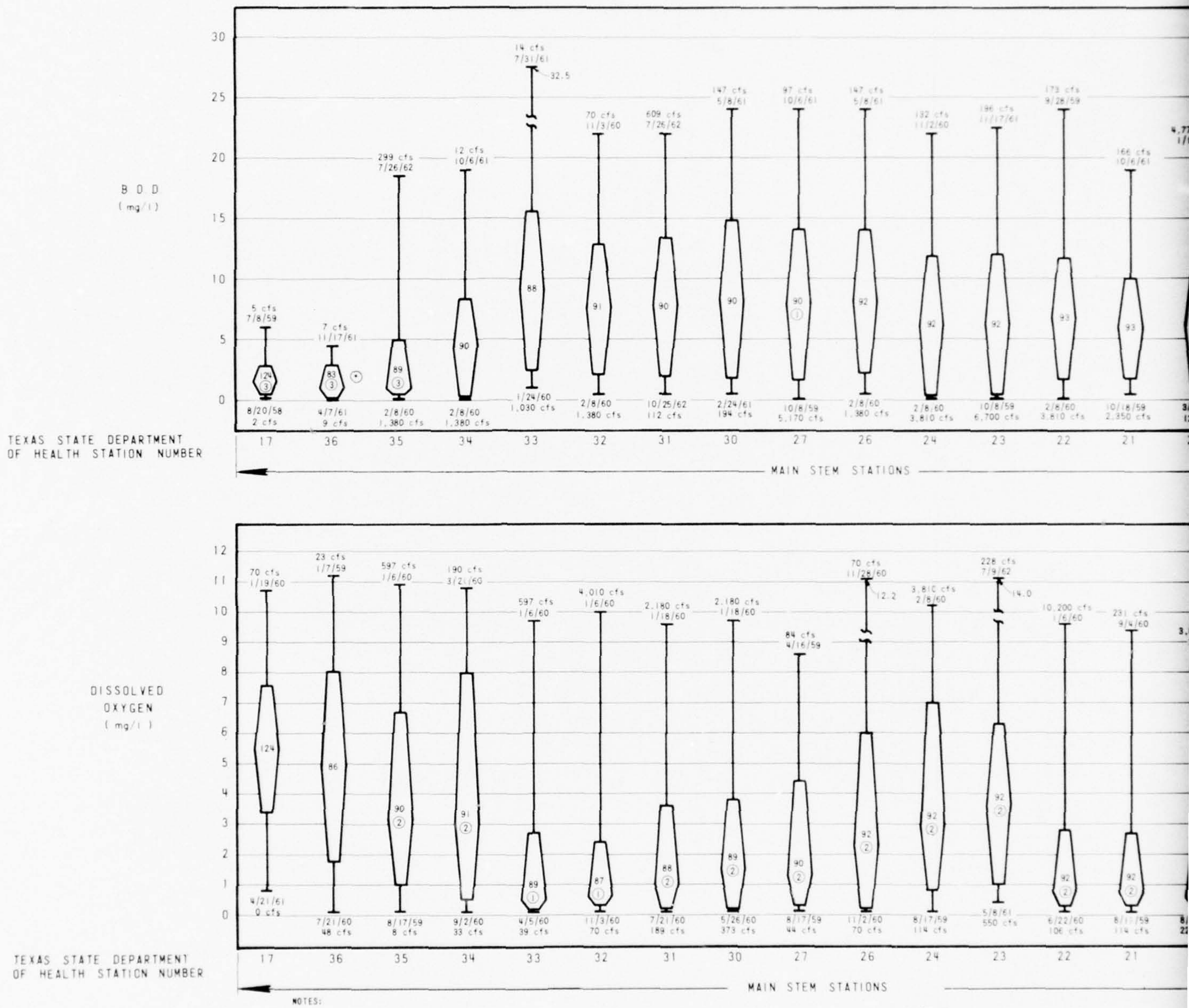


North Central Texas Council Of Governments
UPPER TRINITY RIVER BASIN
COMPREHENSIVE SEWERAGE PLAN

SCHEMATIC DIAGRAM OF EXISTING WATER QUALITY

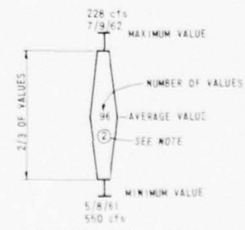
CAMP, DRESSER AND MC KEE General Consultants
FORREST AND COTTON, INC. Associate Consultants
FREESE, NICHOLS AND ENDRESS Associate Consultants

JULY 1970	FIG. III-2

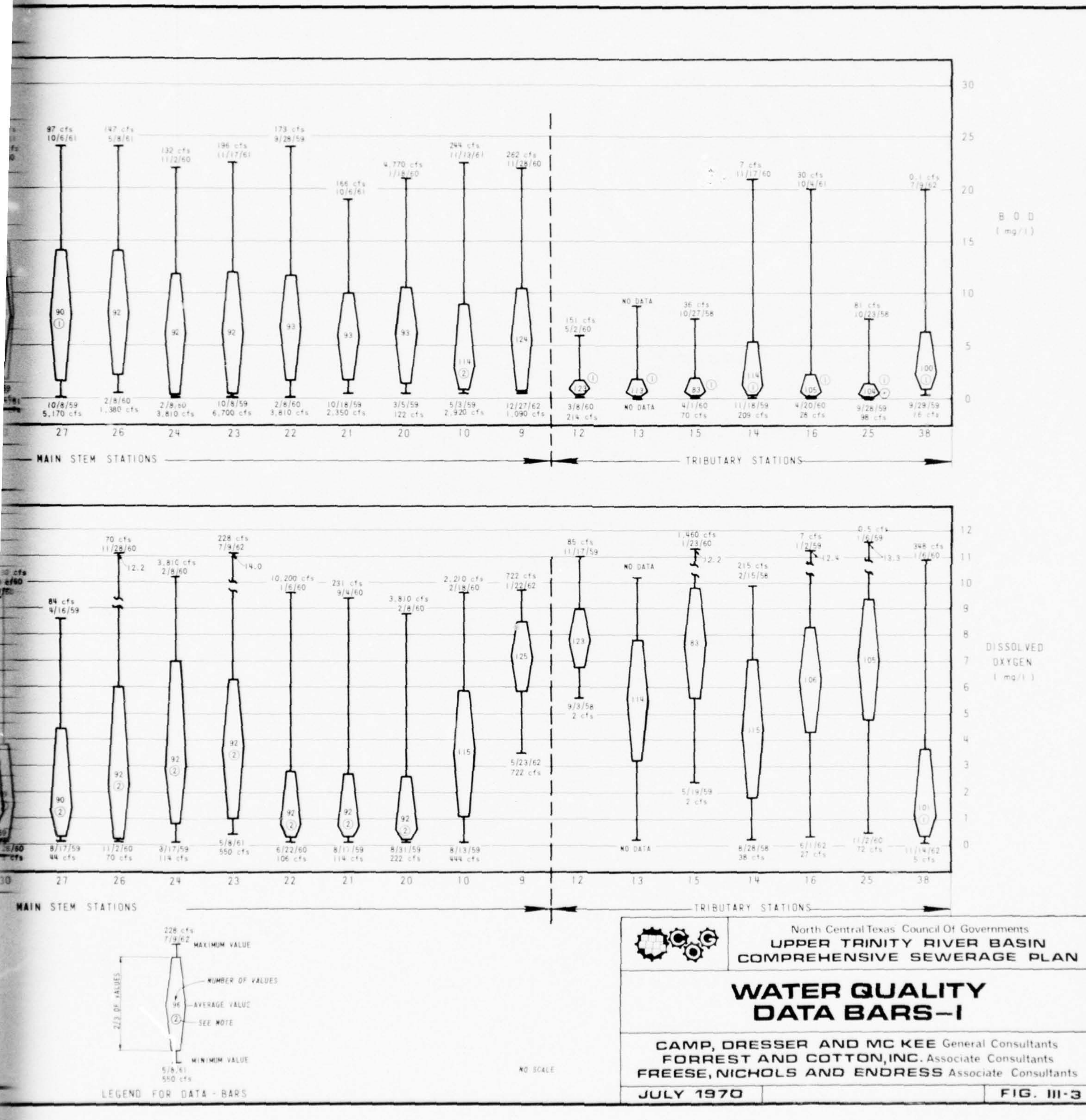


NOTES:

1. ① within the enclosed part of the data-bar indicates that the data was not arithmetically normal, but was geometrically normal. The "average" is the geometric mean or the arithmetic median, both of which coincide.
2. ② indicates that the data was neither arithmetically nor geometrically normal. The upper and lower two-thirds limits were derived by group analysis of the entire range of data. The "average" is a value fixed by weighted analysis of arithmetic mean and mode, geometric mean, and the median number.
3. ③ indicates data was not statistically reliable. Figures shown on data-bar were derived subjectively.
4. ⊙ indicates that one or more actual maximum values were disregarded in the statistical analysis to give more meaningful statistics.
5. Flow values and dates for maxima and minima are actual values reported by the USGS gaging stations which are nearest to the water quality stations. Where flow value reads 0 cfs, actual value reported was less than 0.05 cfs.
6. For locations of sampling stations see schematic diagram, Fig. III-2.



LEGEND FOR DATA-BARS

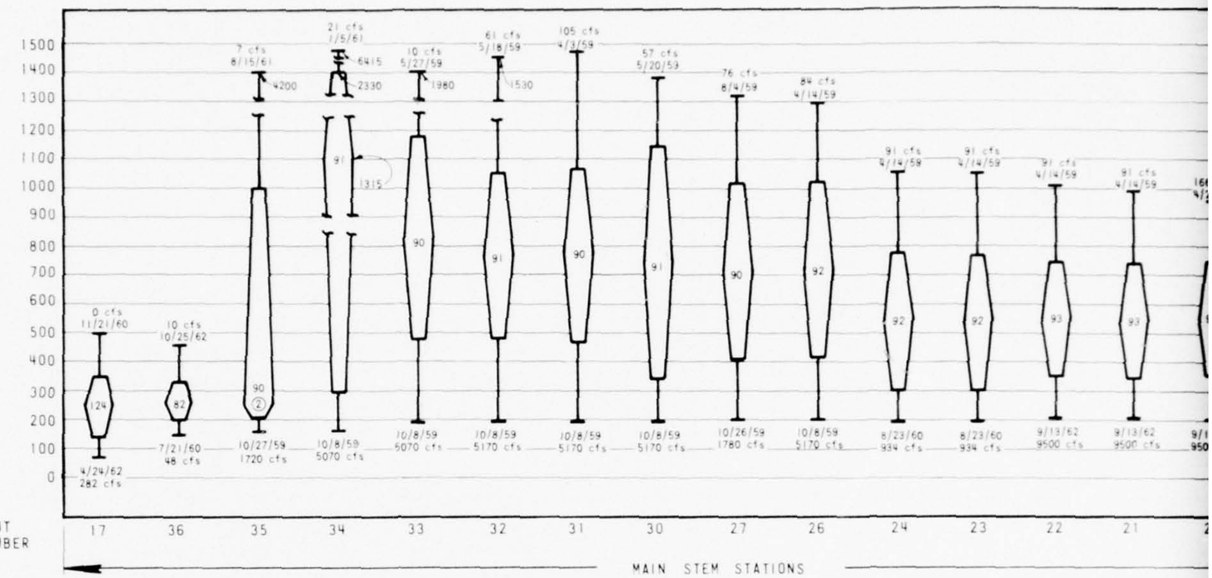


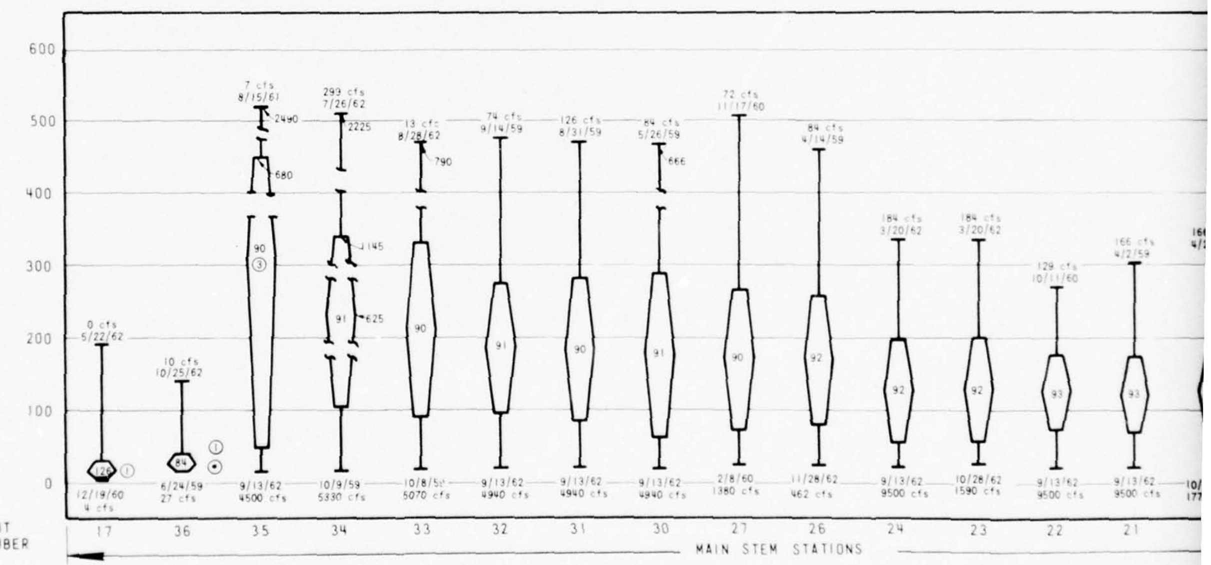
North Central Texas Council Of Governments
UPPER TRINITY RIVER BASIN
COMPREHENSIVE SEWERAGE PLAN

WATER QUALITY DATA BARS–I

CAMP, DRESSER AND MC KEE General Consultants
FORREST AND COTTON, INC. Associate Consultants
FREESE, NICHOLS AND ENDRESS Associate Consultants

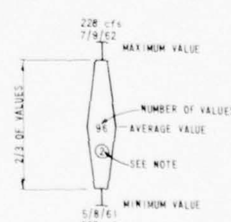
JULY 1970 | FIG. III-3



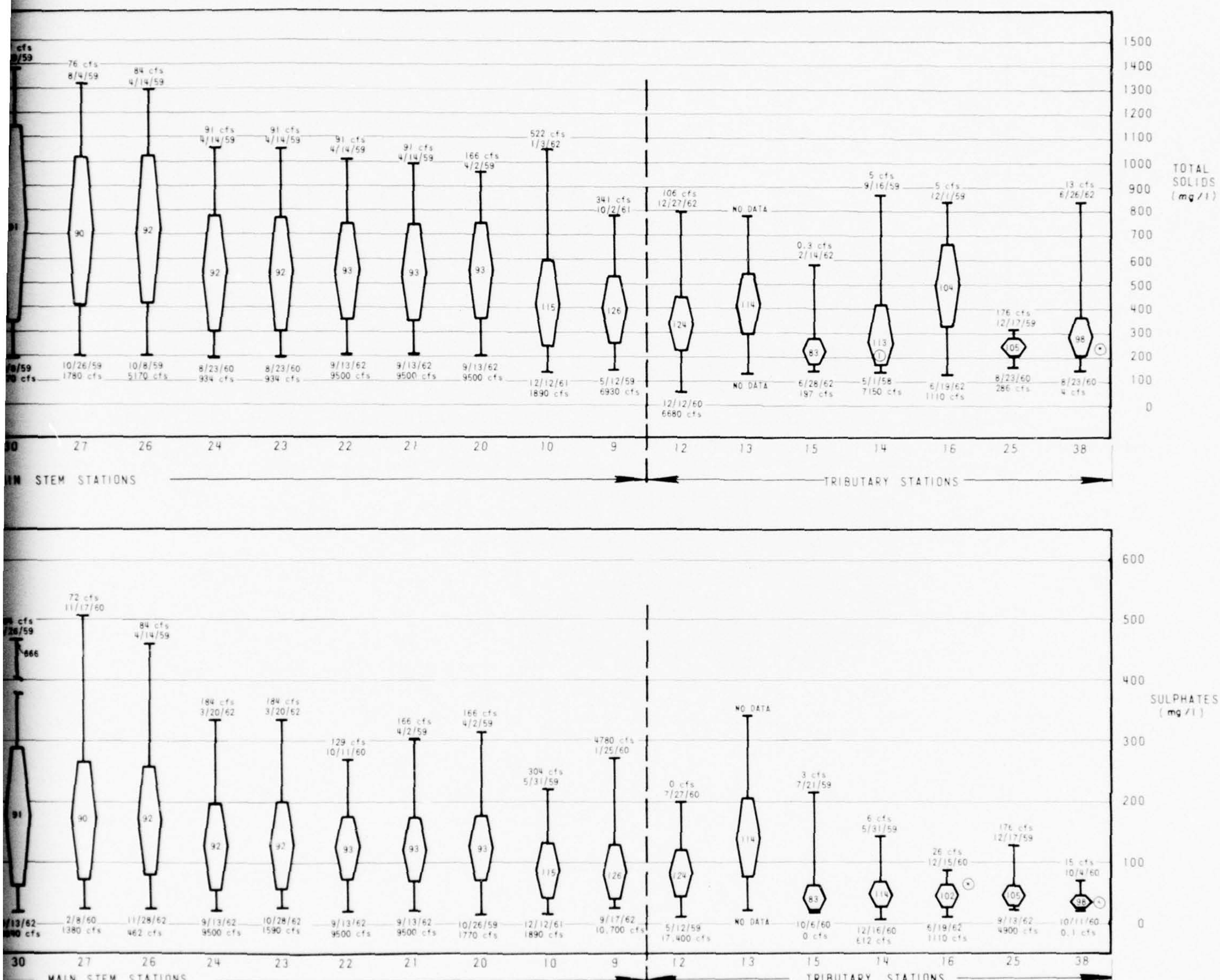


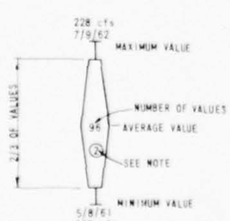
NOTES:

1. ① within the enclosed part of the data-bar indicates that the data was not arithmetically normal, but was geometrically normal. The "average" is the geometric mean or the arithmetic median, both of which coincide.
2. ② indicates that the data was neither arithmetically nor geometrically normal. The upper and lower two-thirds limits were derived by group analysis of the entire range of data. The "average" is a value fixed by weighted analysis of arithmetic mean and mode, geometric mean, and the median number.
3. ③ indicates data was not statistically reliable. Figures shown on data-bar were derived subjectively.
4. ⊙ indicates that one or more actual maximum values were disregarded in the statistical analysis to give more meaningful statistics.
5. Flow values and dates for maxima and minima are actual values reported by the USGS gaging stations which are nearest to the water quality stations. Where flow value reads 0 cfs, actual value reported was less than 0.05 cfs.
6. For locations of sampling stations see schematic diagram, Fig. III-2.



LEGEND FOR DATA - BARS





LEGEND FOR DATA - BARS

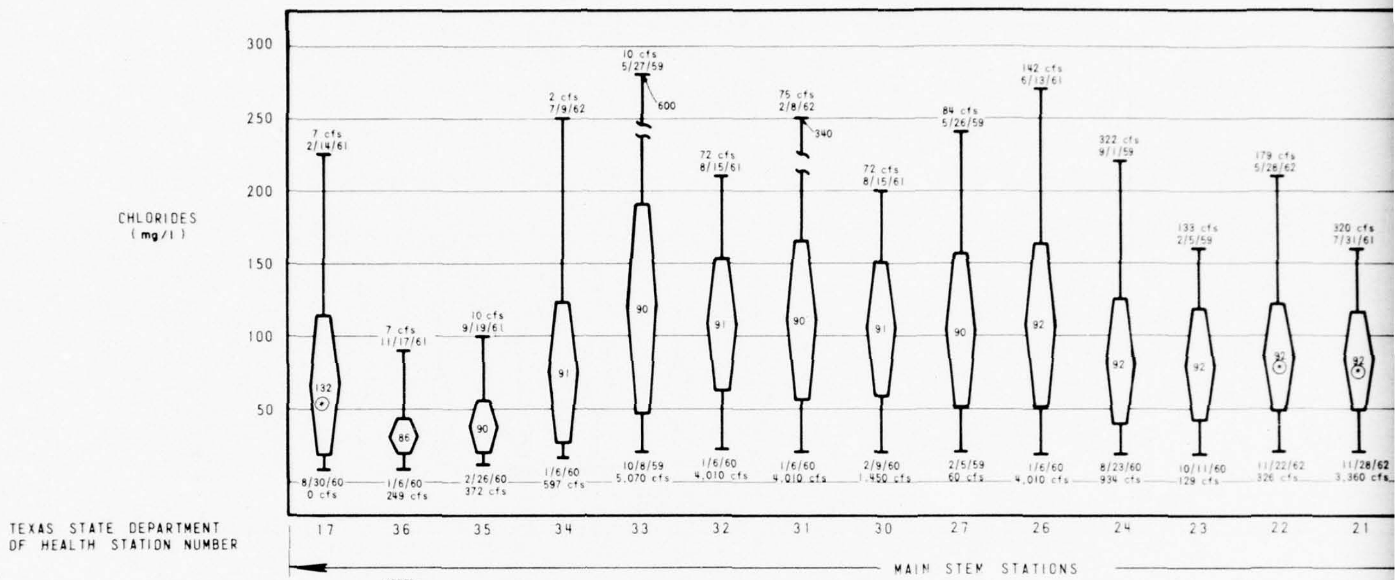
North Central Texas Council Of Governments

UPPER TRINITY RIVER BASIN
COMPREHENSIVE SEWERAGE PLAN

WATER QUALITY DATA BARS–II

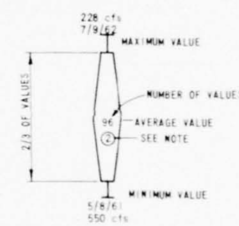
CAMP, DRESSER AND MC KEE General Consultants
FORREST AND COTTON, INC. Associate Consultants
FREESE, NICHOLS AND ENDRESS Associate Consultants

JULY 1970 | FIG.III-4

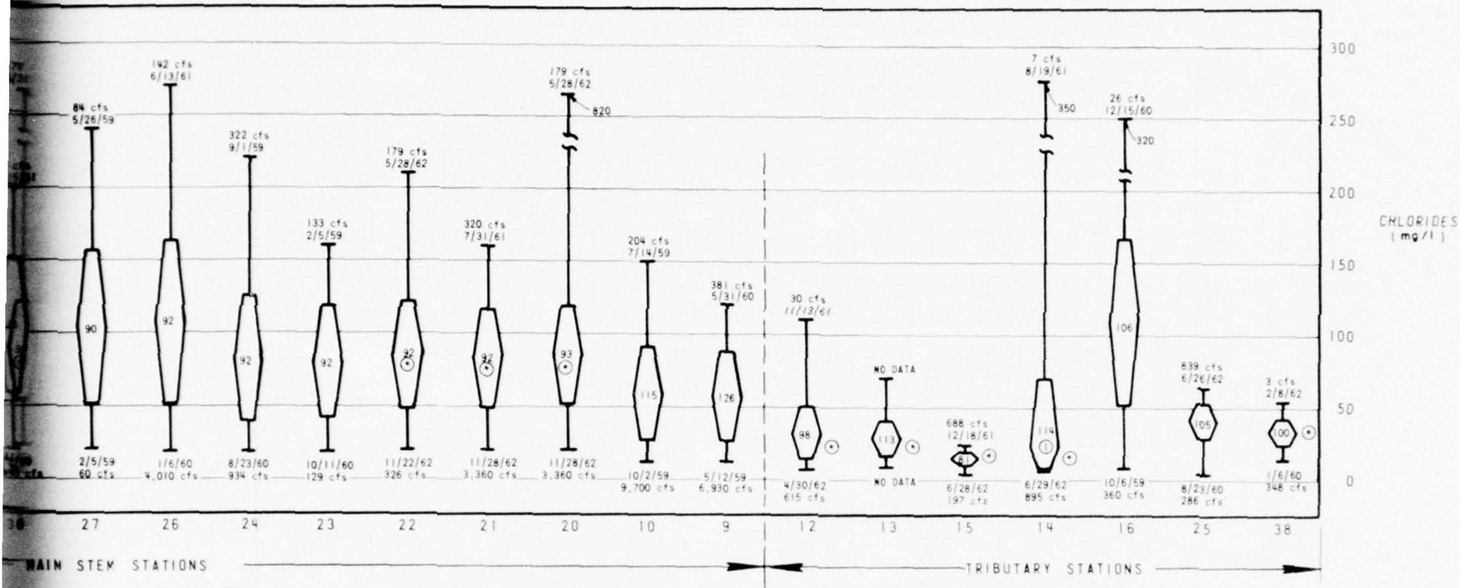


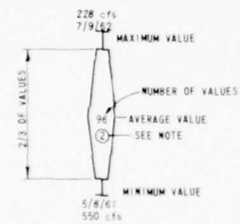
NOTES:

1. ① within the enclosed part of the data-bar indicates that the data was not arithmetically normal, but was geometrically normal. The "average" is the geometric mean or the arithmetic median, both of which coincide.
2. ② indicates that the data was neither arithmetically nor geometrically normal. The upper and lower two-thirds limits were derived by group analysis of the entire range of data. The "average" is a value fixed by weighted analysis of arithmetic mean and mode, geometric mean, and the median number.
3. ③ indicates data was not statistically reliable. Figures shown on data-bar were derived subjectively.
4. ⊙ indicates that one or more actual maximum values were disregarded in the statistical analysis to give more meaningful statistics.
5. Flow values and dates for maxima and minima are actual values reported by the USGS gaging stations which are nearest to the water quality stations. Where flow value reads 0 cfs, actual value reported was less than 0.05 cfs.
6. For locations of sampling stations see schematic diagram, Fig. III-2.



LEGEND FOR DATA - BARS





LEGEND FOR DATA - BARS

NO SCALE

North Central Texas Council Of Governments

UPPER TRINITY RIVER BASIN
COMPREHENSIVE SEWERAGE PLAN

WATER QUALITY DATA BARS–III

CAMP, DRESSER AND MC KEE General Consultants
FORREST AND COTTON, INC. Associate Consultants
FREESE, NICHOLS AND ENDRESS Associate Consultants

JULY 1970 | FIG. III-5

TABLE III-1. SELECTED ANALYSES OF TRINITY RIVER WATER
(Summer Conditions)

Sampling No.	Station Location	Main Stem River Mile	Source of Data	Date	Water Temp. (°F)	D.O. (mg/l)	BOD (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	River Flow (cfs)**
MAIN STEM STATIONS										
4	Downstream from Confluence with Clear Fork	558.4	Fort Worth	7/18/69 8/1/69	79 84	5.0 7.3	12.0 13.0	- -	- -	34 40
12	Downstream from Riverside STP	547.3	Fort Worth	7/18/69 8/1/69	79 83	6.5 2.0	8.0 22.0	- -	- -	- -
15	Downstream from Village Creek STP	532.8	Fort Worth	7/18/69 8/1/69	77 84	2.5 1.5	8.0 36.0	- -	- -	- -
1	Downstream from Confluence with Mountain Creek	507.2	Dallas	7/29/68 8/5/68	81 83	3.0 3.6	19.0 10.0	- -	14.2* 24.4	- -
3	Downstream from Confluence with Elm Fork	500.7	Dallas	7/29/68 8/5/68	81 83	3.4 5.4	13.0 8.0	- -	7.2* 12.0	420 271
4	Upstream from Dallas-White Rock STP's	497.0	Dallas	7/29/68 8/5-68	79 83	5.0 6.0	17.0 10.0	- -	3.0* 10.9	- -
5	Downstream from Dallas-White Rock STP's	494.7	Dallas	7/29/68 8/5/68	81 83	2.8 1.5	21.0 20.0	- -	8.9* 16.1	- -
6	Downstream from Confluence with White Rock Creek	491.8	Dallas	7/29/68 8/5/68	81 83	1.8 0.0	15.0 12.0	- -	12.5* 15.8	703 388
7	Upstream from Dallas-South Side STP	483.2	Dallas	7/22/68 8/19/68	82 82	0.0 1.3	8.0 7.0	- -	9.2* 12.0	- -
8	Downstream from Dallas-South Side STP	478.0	Dallas	7/22/68 8/19/68	82 82	1.0 2.6	9.0 6.0	- -	7.2* 8.5	- -
9	Upstream from Confluence with Ten Mile Creek	473.8	Dallas	7/22/68 8/19/68	82 83	2.6 2.9	7.0 6.0	- -	8.6* 11.5	- -
8-0480 (USGS)	Near Fort Worth Station No.4	558	TWQB	7/24/69 8/14/69	88 104	0.6 5.4	3.8 4.2	1.6 1.2	0.46 0.36	32 20
8-0495 (USGS)	Near TSDH Station No. 27	515	TWQB	7/23/69 8/14/69	90 93	4.0 4.6	14.0 17.0	29.0 54.0	10.0 22.0	206 120
8-0574.1 (USGS)	Near Dallas Station No. 6	492	TWQB	7/23/69 8/12/69	88 88	0.4 0.5	22.0 11.0	45.0 36.0	17.0 13.0	531 397
8-0625 (USGS)	Near Rosser and TSDH Station No. 10	452	TWQB	7/23/69 8/12/69	88 88	3.6 3.4	12.0 19.0	31.0 21.0	16.0 18.0	694 430
8-0627 (USGS)	At Trinidad Near TSDH Station No. 9	392	TWQB	7/23/69 8/12/69	90 92	6.5 3.4	16.0 10.0	17.0 21.0	11.0 12.0	650 510
TRIBUTARY STATIONS										
2	Elm Fork	505	Dallas	7/29/68 8/5/68	80 83	6.8 7.2	13.0 4.0	- -	0.6* 0.6	- -
8-0620 (USGS)	East Fork Near TSDH Station No. 14	460	TWQB	7/23/69 8/12/69	88 90	7.2 8.7	20.0 19.0	39.0 45.0	30.0 36.0	20 25

*Orthophosphates determined by Dallas.

**River flows shown where available.

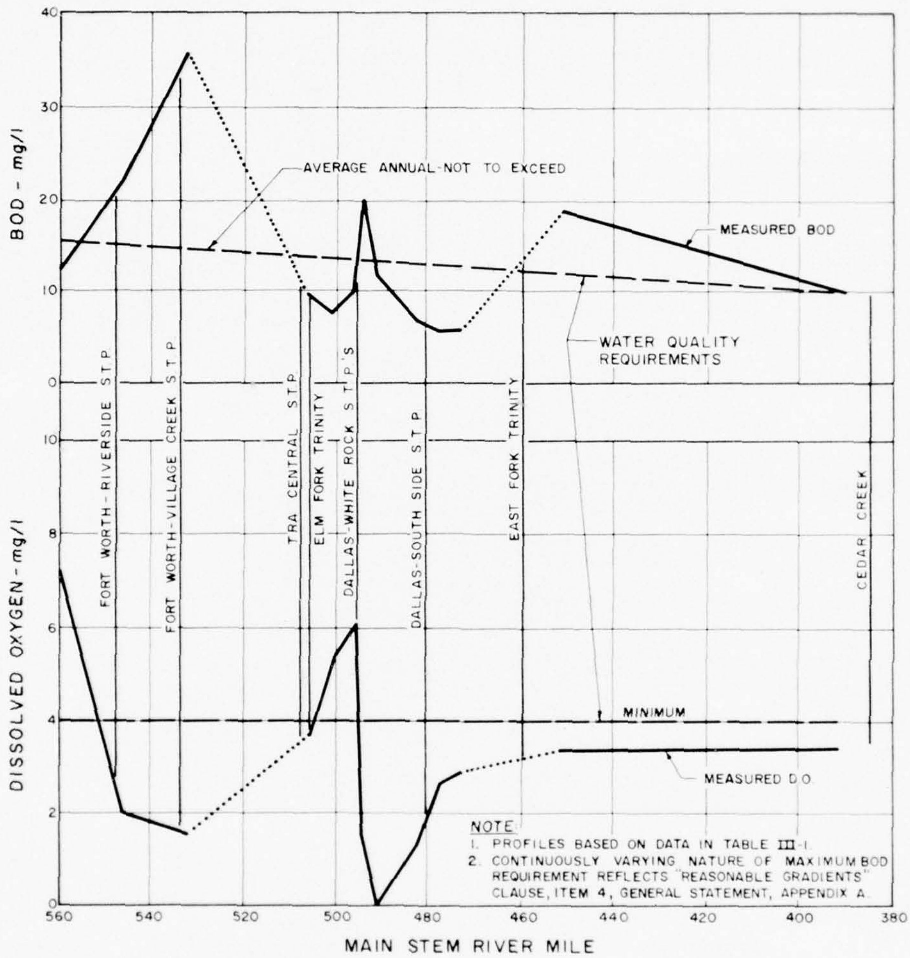


FIG. III-6 TRINITY RIVER WATER QUALITY PROFILES (SUMMER CONDITIONS)

(MEASURED BOD AND D.O. PROFILES REFLECT CONDITIONS OCCURRING DURING THE MONTHS OF JULY AND AUGUST OF 1968 AND 1969. MEASUREMENTS TAKEN AT OTHER TIMES MAY INDICATE RIVER CONDITIONS TO BE BETTER OR POORER THAN SHOWN BELOW FORT WORTH OR AT ANY OTHER LOCATION.)

Inspection of the analyses in general indicate heavy organic pollution of the river and its principal tributaries the Elm Fork and the East Fork. In addition, extremely high values for nitrate and phosphate concentrations are noted, indicating a great potential for eutrophication of river waters and impoundments. These analyses, together with visual observations of the river, indicate that water quality in the Trinity River has not materially improved since the 1960 TSDH survey.

The City of Dallas has compared low stream flows in the Trinity River to the discharges of wastewater from the City treatment plants. Such data indicate that there have been many years when low flows in the river were less than the wastewater effluents discharged from the treatment plants. A similar situation exists in the river below Fort Worth. For this reason the quality of effluents from the treatment plant and industries is especially critical to the water quality in the river. Under summer conditions which occur for extensive periods of time in the study area, the water quality in the Trinity River and its tributaries is generally unsatisfactory.

Fish and other desirable aquatic wildlife are generally unable to propagate and to survive when dissolved oxygen levels remain below about 4.0 mg/1. It is evident from available analyses that dissolved oxygen levels are generally below that figure and frequently reach zero, particularly during the summer. It is not surprising therefore, that numerous fish kills are reported in the Trinity River and its tributaries. Recent fish kills have been reported at Mountain Creek Lake and at Duck Creek in Garland. The State Parks and Wildlife Department has indicated that more fish would probably have been killed by pollution, except that the fish have already left many of the streams. It is reported that only the sturdy gar and catfish can tolerate many reaches of the Trinity River.

Not all pollution in the Trinity River is caused by municipal and industrial effluents and surface runoff. Landfills and dumps located along the river contribute to pollution and the impairment of aesthetic quality and are discussed in Chapter XI. Floating materials of all kinds as well as junk and debris are found along the river. The origin of some of this material is a mystery, but it has been found elsewhere that inhabitants occasionally use streams, lakes and rivers as dumping grounds.

Trinity River Water Quality Zone No. 0802. This water quality zone includes the entire West Fork of the Trinity River as well as that portion of the main stem of the Trinity River above Rosser (mile point 451.6.) This reach is approximately 250 miles in length originating in the far northwest corner of the study area and traversing the metropolitan areas of Fort Worth and Dallas. Upstream from Fort Worth the watershed is relatively sparsely populated and agricultural uses of the land predominate. Downstream portions of the watershed are highly developed and continuing to develop rapidly.

Water quality requirements limit the minimum D.O. concentration in this reach to 4.0 mg/1 and the maximum BOD to 15.0 mg/1.

Principal tributaries to the river in this reach are the Clear Fork, Marine Creek, Village Creek, Mountain Creek, and Elm Fork, White Rock Creek, Ten Mile Creek and East Fork Trinity. As might be expected, the water quality of the Trinity River and its tributaries upstream from Fort Worth is somewhat better than it is downstream. Nevertheless, it is evident from inspection of Fig. III-3 that D.O. levels approach zero at every station at some time during the year and most commonly

during low flow high temperature conditions. Inspection of Fig. III-6 indicates that with the exception of reaches above Fort Worth and immediately upstream from Dallas, D.O. levels under representative summer conditions do not meet minimum State requirements. Maximum allowable BOD levels are exceeded in major portions of this reach of the river also. Concentrations of nitrates and phosphates increase greatly between Fort Worth and Arlington, this effect being attributed primarily to the effluents from the Fort Worth and Arlington Sewage Treatment Plants. It should be noted, however, that the relatively low concentrations of these nutrients at Sampling Station 4 in Fort Worth are still sufficiently high to pose eutrophication problems. No apparent effect on BOD or D.O. levels from the TRA Central Treatment Plant is indicated.

Between Dallas Sampling Stations 4 and 5 (mile points 497.0 and 494.7 respectively), the effect of the Dallas-White Rock Treatment Plant effluent is noted in a drastic decrease in the dissolved oxygen content accompanied by a rise in BOD concentrations. Downstream from the Dallas-White Rock plants, the D.O. levels reach zero. Records indicate that at Dallas Sampling Station 6, D.O. levels have reached zero in 1966, 1967 and 1968. It is interesting to note that in the winter month of January 1969, D.O. levels of zero were recorded at Dallas Sampling Stations 1, 5 and 6.

Downstream from Sampling Station 6, the river begins to recover with increasing dissolved oxygen levels and decreasing BOD levels noted. Little or no effect of the Dallas South Side Treatment Plant on river quality is noted. Below the confluence with the East Fork, however, an increase in BOD levels is once again evident, and this may be attributed to the high concentrations in the East Fork as discussed below.

Trinity River Water Quality Zone No. 0801. Downstream from Rosser, water quality requirements remain at a minimum dissolved oxygen concentration of 4.0 mg/1, but maximum BOD concentration is lowered to 10 mg/1. This reach extends from Rosser to Trinity Bay on the Gulf of Mexico. As may be seen of Fig. III-6, water quality requirements for both D.O. and BOD are not met downstream from Rosser to the limits of the study area (mile point 379.0). With regards to the dissolved oxygen content, water quality tends to stabilize at a level somewhat below minimum requirements, and BOD levels exceed the maximum allowable. Of particular interest in this reach, however, are recorded concentrations of nitrates and phosphates. Nitrate levels range from 17 to 31 mg/1, and phosphates range from 11 to 18 mg/1, all of which are from 10 to 100 times the concentrations which are considered to be conducive to excessive growth of algae and other undesirable aquatic plants. It is evident that without the removal of these nutrients, severe eutrophication problems in reservoirs and other impoundments along the river may be anticipated.

Monthly water samples from May 1966 to November 1969, were taken from the recently completed Cedar Creek Reservoir, a municipal raw water supply for Fort Worth. Chemical analyses indicate that the Cedar Creek raw water is generally superior in quality to that of the Fort Worth Lake Worth raw water source. A chemical analysis for nitrates, made on November 7, 1969 showed a concentration of 1.0 mg/1. A January, 1970 report by Alvord, Burdick & Howson, consulting engineers indicate "algae growths in Cedar Creek will be of about the same order as found in Lake Worth Reservoir." This report also indicates that "recognition must be given to the potentialities that the algae growths in the Cedar Creek reservoir water may cause short filter runs at times." Although no analytical values were reported for D.O. or

BOD median values for sulphates, chlorides, and total dissolved solids were obtained (12 mg/l, 17 mg/l, and 115 mg/l, respectively).

Elm Fork Trinity River Water Quality Zone No. 0804. The Elm Fork Trinity enters the main stem of the Trinity River at approximately mile point 505.8 at which point the West Fork Trinity River is considered to become the Trinity River. Water quality requirements call for concentrations of 4.0 mg/l for both dissolved oxygen and BOD, and it is evident that while D.O. requirements are met as far as the analyses shown in Table III-1 are concerned, BOD levels are equalled or exceeded. The generalized data shown on Fig. III-3 indicate that D.O. levels for TSDH Station 25 have been as low as about 0.5 mg/l and BOD levels have reached about 7.5 mg/l. At upstream Station TSDH No. 16, minimum. D.O. levels are about the same, but maximum BOD levels have reached 20 mg/l. These data for TSDH Station 16, which is upstream from Garza-Little Elm Reservoir, indicate that organic pollution is entering the lake.

At Dallas Sampling Station 2, orthophosphate levels are reported to be about 0.6 mg/l which, though lower than values shown for the main stem of the Trinity River, are still quite high and conducive to eutrophication problems.

East Fork Trinity River Water Quality Zone No. 0803. The East Fork of the Trinity River enters the main stem about eight miles upstream from Rosser (mile point 460.0) and drains a very rapidly growing portion of the Dallas metropolitan area. Water quality requirements in this reach call for a minimum dissolved oxygen concentration of 4.0 mg/l and a maximum BOD concentration of 10.0 mg/l. At TSDH Sampling Station No. 15, the data indicated on Fig. III-3 show that BOD levels fall within State requirements and that only a small number of analyses have indicated levels of dissolved oxygen below 4.0 mg/l. Downstream, however, at TSDH Station No. 14, a large number of samples indicated D.O. levels below 4.0 mg/l with an extreme value of approximately 0.2 mg/l recorded. BOD levels have gone above 20 mg/l. Data indicated in Table III-1 show consistently high D.O. levels, well above the 4.0 mg/l minimum, but BOD levels are recorded at about 20 mg/l or about double maximum allowable concentration. This condition may be attributed to the effect of photosynthetic activity and to treatment plant effluents in the watershed. Concentrations of nitrate and phosphate in the East Fork near Station No. 14 are extremely high and contribute greatly to the potential problems of eutrophication both in the lower reaches of the East Fork and in the main stem of the Trinity River.

With the completion of Lake Ray Hubbard characteristics in the East Fork are expected to approach those of the West Fork. This condition is expected because most of the flow during summer months will be effluent from sewage treatment plants in the area such as the Rowlett Creek and Duck Creek Treatment Plants.

Bacteriological Quality. The Texas Water Quality Board is maintaining a bacteriological surveillance of all major rivers in Texas including the Trinity River which was formerly carried out by the Texas State Department of Health. Stations sampled by the TSDH within the study area include TSDH Station No. 10 near Rosser (river mile 451.6) and at TSDH Station No. 9 at Trinidad (river mile 392.0). Analysis of the samples collected at these stations between 1967 and 1969 are shown in Table III-2.

It is evident from inspecting the data presented in Table III-2 that the count of most probable numbers (MPN) of both total and fecal coliform varies over a very wide

TABLE III-2. BACTERIOLOGICAL QUALITY OF THE TRINITY RIVER IN THE NCTCOG STUDY AREA

Sampling	TSDH Station 8 (River Mile 374.5) MPN Total Coliform Per 100 ml	TSDH Station 8 (River Mile 374.5) MPN Fecal Coliform Per 100 ml	TSDH Station 9 (River Mile 392.0) MPN Total Coliform Per 100 ml	TSDH Station 9 (River Mile 392.0) MPN Fecal Coliform Per 100 ml	Stream Condition
5/18/67	49,000	-	23,000	-	Normal
2/13/68	542,000	49,000	70,000	10,900	Normal
6/27/68	79,000	49,000	49,000	3,450	High - Muddy
8/7/68	1,720	490	700	460	Low - Dirty
10/17/68	17,200	2,210	22,100	4,900	Normal
11/27/68	13,000	1,410	13,000	4,900	High - Muddy
12/17/68	34,800	7,900	7,000	1,410	Normal
2/6/69	160,900	7,900	160,900	160,900	Normal
4/29/69	23,000	7,900	130,000	7,900	High - Muddy
6/10/69	91,800	7,900	160,900	22,100	High

Note: Sampling program conducted by Texas State Department of Health.

range. At each sampling station, the count of total coliform organisms exceeded 20,000 per 100 ml for seven of the nine determinations made at each station. As stated in the water quality requirements presented in Appendix A, raw water surface supplies to receive treatment for drinking purposes shall not be deemed unsatisfactory where total coliform organisms do not exceed 20,000 per 100 ml and the fecal coliform organisms do not exceed 2,000 per 100 ml. Such concentrations are not considered to be the sole criteria on which the quality of waters is based, but available analyses do indicate that there is evidence of substantial fecal pollution in the Trinity River and that the Upper Trinity River does not meet minimum requirements for raw water supplies.

Even some public water supply reservoirs are not free of excessive bacterial contamination. It is reported that Bachman Lake has coliform counts as high as 23,000 per 100 ml. By contrast Lake Tawakoni has a reported very low count of 5.8 per 100 ml. It should be noted that no standards have yet been set for pathogenic viruses which exhibit greater resistance to disinfection than bacteria.

Many lakes and reservoirs in the study area are used for both water supply and recreation. The U.S. Public Health Service has established as a guideline a count (MPN) of total coliform bacteria at 1,000 per 100 ml for swimming and wading. Texas has not established limiting counts for such purposes, but warnings have been issued that swimming or wading the such streams and lakes as Bachman's Creek, White Rock Creek, Turtle Creek, Lake Cliff, White Rock Lake and Bachman Lake is dangerous. Bacteria and viruses present in polluted surface waters can cause a number of gastrointestinal disorders.

Water Quality Monitoring Plan. A water quality monitoring plan for the Upper Trinity River Basin has been prepared for the NCTCOG by the TRA and their consultants, Forrest and Cotton, Inc. A review of the discussion draft of this plan has been conducted by the General Consultants and brief comments on recommendations made therein are listed below:

1. The selection of sampling station locations appears ample to yield meaningful data on the river.

2. The use of permanent monitoring stations on the Trinity River to indicate lon-term trends in water quality is needed. It may be found desirable to increase the number of permanent monitoring stations to provide more simultaneous data. Additional permanent stations might be located upstream from the Fort Worth Village Creek Plant and near Trinidad.

3. The use of mobile monitoring units to supplement data obtained from the permanent stations appears appropriate, and substitution of one or more such units by permanent stations as discussed above might be desirable.

4. Considerable emphasis should be given to nitrogen determination, with all four standard nitrogen analyses made at a number of locations including the permanent stations.

5. Consideration should be given to phosphorus determinations at all stations, with not only total but soluble phosphorus determined.

6. Pesticides and herbicides should be monitored at several additional locations particularly above major reservoirs if conditions indicate. Heavy metals should be monitored.

7. Both total and fecal coliform analyses should be made and they should probably be made at each permanent and mobile station and on each grab sample.

8. The functioning of the proposed monitoring system and equipment requirements appear to be thoroughly considered.

PESTICIDE LEVELS

During the water year 1968,(October, 1967 to September, 1968), the Texas Water Development Board initiated a reconnaissance-level program with the U.S. Geological Survey to collect data on the concentrations of various pesticides and herbicides in major streams throughout Texas. This program includes the collection of between 6 and 12 samples per year at a number of sampling stations. Within the study area, samples have been taken at seven locations.

Analysis performed on samples taken near Rosser (mile point 451.6) indicated that less than half of the listed insecticides and herbicides yielded any measurable concentration. Measurable concentrations of DDT; Lindane; Chlordane Dieldrin; 2,4-D and 2, 4, 5-T were recorded, but all of these were well within concentrations permissible in public water supplies as listed in "Water Quality Criteria-Report of the National Technical Advisory Committee to the Secretary of the Interior" in 1968. Thus, it appears that pesticides in the Trinity River do not pose a public health hazard at present.

CONCLUSIONS

The Trinity River is grossly polluted from wastes discharged in the vicinity of the Dallas-Fort Worth metropolitan area as indicated by both chemical and bacteriological analysis. For most of its length within the study area the Trinity River and its principal tributaries do not meet established State stream water quality requirements. In addition, concentrations of nutrients such as nitrates and phosphates which are conducive to eutrophication problems as discussed hereinafter, exceed levels which have been found to create objectionable conditions. Based on these water quality conditions, most of the main stem of the Trinity River as well as portions of the Elm Fork and East Fork are considered to be unsuitable for such uses as contact and non-contact recreation, domestic raw water supply, industrial supply and cooling water (without pretreatment), aesthetics and fishing. In addition, a number of lakes and smaller tributary streams do not meet water quality requirements.

REFERENCES

1. Dupuy, A.J., Manigold, D.B. and Schulze, J.A., "Biochemical Oxygen Demand

Dissolved Oxygen, Selected Nutrients, and Pesticide Records of Texas Surface Waters, 1968," Texas Water Development Board, Report 108, Feb., 1970.

2. Leifeste, D.K. and Hughes, L.S., "Reconnaissance of the Chemical Quality of Surface Waters of the Trinity River Basin, Texas," Texas Water Development Board, Report 67, Dec., 1967.

3. National Technical Advisory Committee to the Secretary of the Interior, "Water Quality Criteria," FWPCA, Washington, D.C., April, 1968.

4. Smallhorst, D.F. and Goff, J.D., "Upper Trinity River Sewage and Industrial Wastes Survey," Texas State Department of Health, Division of Water Pollution Control, July 1, 1960.

5. Texas Water Quality Board, "Water Quality Requirements - Volume 1, Inland Waters," Austin, Texas, June, 1967.

6. U.S. Geological Survey, "Water Resources Data for Texas - Part 2, Water Quality Records," Austin, Texas, 1967.

7. "Waste Water Treatment," Dallas, Texas, 1966.

EXISTING MAJOR CAUSES OF POLLUTION

Water pollution in the North Central Texas region is caused primarily by discharges of municipal sewage and industrial wastewater and by surface runoff from urban and rural areas. Most industrial wastewater in the study area finds its way into municipal sewerage systems for subsequent treatment along with city sewage. The few significant wastewater-producing industries which do not discharge to sewerage systems are discussed below.

Surface runoff constitutes a source of unknown but great pollution occurring during wet weather periods. By its very nature, it occurs throughout the study area and elsewhere rendering it most difficult to control.

The largest concentrated sources of pollution are the discharges from municipal sewerage systems. Because they are concentrated at specific and readily identifiable locations, they can most readily be subjected to treatment processes.

Additional causes of pollution include discharges from private sewerage systems such as at mobile home parks, leaching from sanitary landfills and dumps, and improperly operating septic tank systems.

MUNICIPAL SEWAGE

Municipal sewage is presently collected and treated at 132 locations in the study area as discussed in Chapter IV. These systems serve over 80 percent of the population and provide sewage treatment with varying effectiveness. Total estimated municipal sewage flow in the study area at present averages about 246 mgd as shown in Chapter V.

The effect of the Dallas and Fort Worth sewage treatment plants on the water quality of the Trinity River was discussed earlier in this Chapter. In-depth monitoring studies would no doubt show similar effects from other plants as well. Effluents or discharge from all conventional sewage treatment plants contain concentrations of BOD, ammonia, nitrates, phosphates, bacteria, viruses and other substances. For a river such as the Trinity to maintain dissolved oxygen levels of 4.0 mg/l throughout the year, effective removal of BOD, ammonia and other oxygen consuming substances may be required. The conventional 5-day, 20°C BOD measurement commonly used to evaluate oxygen requirements of a wastewater is no longer considered adequate when used alone. The total oxygen demand should be determined to permit proper treatment requirements to be determined. A full discussion of sewage characteristics is given in Chapter V.

Effluents from every plant in the study area go to a nearby watercourse and, depending upon the degree of treatment actually provided, may have a detrimental effect upon it. At the present time most of these treatment plants are designed to provide secondary (biological) treatment as required by the TWQB. Further treatment will probably be necessary in many cases to achieve water quality goals.

Each major treatment plant is described in Chapter IV, and a discussion of the adequacy of each plant is presented in Chapter VIII.

INDUSTRIAL WASTEWATER

Industrial wastewaters considered herein are those which are discharged by industries directly into watercourses; that is, wastewaters which do not go into municipal sewerage systems. Industrial wastewaters discharging into municipal systems are considered to be included in the municipal sewage.

Information on industrial permits in the study area was obtained from the Texas Water Quality Board (TWQB).Lists of known or suspected sources of industrial wastewater were obtained from NCTCOG files, from County Health Departments, City officials, and from data previously obtained by the Associate Consultants.

From such information selection was made of those sources of wastewater considered significant and requiring further investigation. An introductory letter was sent to each of these firms by the NCTCOG explaining the general purpose of the study and introducing the consultant. Additional information permitted the deletion of some wastewater sources from further consideration for reasons such as going out of business, or changing waste disposal practices. For the remaining industries, interviews were held and, with a few exceptions, waste treatment or disposal facilities were inspected.

Existing industrial wastewater contributors discharging directly to watercourses and not considered significant include Bell Helicopter (Hurst Plant), Stauffer Chemical Company, Miller Brewing Company, and Royal Tile Manufacturing Company.

Individual descriptions of the seven industrial wastewater contributors in the North Central Texas region which are considered significant are presented below. Locations of these industries are shown on Figs. IV-1 and IV-2 and schematically on Fig. III-2. Questionnaires containing data obtained from interviews and other sources are

included in Appendix C for all these plants with the exception of the Vought Aeronautics plant.

American Cyanamid Company. This plant manufactures inorganic chemicals on the near north side of Fort Worth. An average wastewater flow of about 1 mgd is discharged directly into the West Fork Trinity River through a 24-in outfall line. An additional portion of wastewater is evaporated and the chemical content recovered through crystallization. It is reported that this process reduces the total solids in the effluent by about 95 percent. No organic wastes are included in the wastewater flow. The effluent has a total solids content of about 2,000 ppm and a sulphate content of about 1,300 ppm. These values are well within the limits set by TWQB statutory permit.

American Manufacturing Company of Texas. This plant in the northeast industrial section of Fort Worth discharges an estimated average wastewater flow of about 216,000 gpd, which flows through a combination of open ditches and closed drainage lines into West Fork Trinity River.

The waste is principally from the manufacture of ordinance materials such as bombs and rockets. Components of the waste include light cutting oils which float on water and heavy grease which is heavier than water.

The wastewater is passed through an earthen settling pond and discharge is beneath a metal skimming weir. Lime is added to a portion of the waste before it reaches the settling pond. Test results obtained from the Texas State Department of Health show consistently high concentrations of suspended solids and high content of oily matter. BOD values of 135 ppm and 154 ppm were obtained in two tests. For an average flow of 216,000 gpd, the BOD load at 140 ppm would amount to about 250 lbs per day.

This industry has no known waste discharge permit from TWQB.

The practice has been to periodically clean out sediments from the settling pond with clamshell bucket or dragline, but this stirs up sediment and results in temporarily making conditions worse. The company plans to improve this condition in the future by use of a steel holding tank so that the pond can be taken out of service for cleaning. A steel tank for this purpose was reported to be on order. A product with the trade name "Treat-o-Light" has been used to separate soluble oil but has resulted in breaking down the heavy grease and releasing talc therefrom. The talc is considered to be the main factor in the high suspended solids content of the wastewater. The use of "Treat-o-Light" has been discontinued recently.

The company is interested in finding a feasible pretreatment method of reducing suspended solids and believes that if this can be done the wastewater can then be discharged into the City sanitary sewer system. It would appear that the oil content must also be reduced before this solution would be acceptable in the sewerage system.

Fort Worth Refining Company (Premier). This oil refinery is located in the northeast industrial section of Fort Worth. Wastewater from various plant operations as well as surface drainage from the plant area discharge through an outfall line directly into the West Fork Trinity River. Average waste flow is about 206,000 gpd. The wastewater is considered inorganic in nature. Limited test results indicate conditions ranging from

those barely meeting TWQB waste discharge permit limitations to those somewhat in excess of permit limitations.

Nipak, Inc. This plant is located in Navarro County, outside the study area, and holds a TWQB permit to discharge waste into the Trinity River. Nipak, Inc., has been included in this discussion because of its location a short distance upstream of the proposed Tennessee Colony Reservoir, and because of the high nutrient content of its wastewater. This plant produces a commercial agricultural fertilizer. The average wastewater flow is about 630,000 gpd and results from the following processes:

(1) Cooling tower blow-down

(2) Backwash from sand filters

(3) Boiler blow-down

(4) Wash-down water from bagging sections, and process condensate.

The quality of the wastewater discharge fails to comply with the TWQB permit limitations in several respects. The permit allows free ammonia up to 2.0 ppm, whereas test results have shown the free ammonia content in the waste to be about 203 ppm. The permit allows 49 ppm for all nitrogen, and test results on the wastewater have shown about 324 ppm. The average rate of flow for waste discharge permitted by the TWQB is 332,000 gpd, whereas the actual rate of waste discharge averages about 630,000 gpd. Recent BOD analyses showed a concentration of 30 ppm which exceeds the permit (20 ppm). Suspended solids concentrations are very low.

Procter and Gamble, Inc. This plant is located south of the downtown business section of Dallas adjacent to the Trinity River. An average of about 145,000 gpd of wastewater is discharged from two sources (called the North and South systems) into open channels leading into the river. The South system consists of wastes from the processing of food products and edible oil refining. The North system carries wastes from soapmaking and household laundry product formulation. Based on the average allowable flow, under the terms of the TWQB waste permit, the South system would contribute about 68 percent of the total wastewater flow and the North system about 32 percent. No recent test data on discharged wastewater were available. A visual inspection was made of each discharge point. If we assume that the BOD of the wastewater corresponds to TWQB permit restrictions (940 ppm North; 1,888 ppm South) and discharge quantities are proportional to allowable discharge rates, then the wastewater would on an average day contain about 1,920 lb of BOD. Similarly the suspended solids would average about 1,000 lb per day.

Company officials have indicated they expect the wastewater discharge permit to be amended with more stringent requirements in the near future. Planning is currently under way to eliminate the discharge of untreated wastewaters.

Texas & Pacific – Missouri Pacific Railroad Company. Wastewaters principally from engine washing and some washing from diesel shops are held in an earthern basin to allow oil and grease to rise to the top. Pump suction from beneath floating oil discharges into the Clear Fork of the Trinity River near West Vickery Boulevard. Average wastewater flow is about 288,000 gpd.

Limited test results (not recent) are quite variable, with tests showing BOD values of 306 ppm and 40 ppm. Suspended solids were above values allowed by the waste discharge permit. The company's representative believes present quality has improved due to changes in engine-washing procedure within the past two years. An acidic spray used to cut oil and grease is followed by an alkaline detergent wash. No recent lab results are available. A separation unit is planned and is included in the company's 1971 budget. It is the company's belief that the waste will be acceptable for discharge to the City sanitary sewer system if objectionable oil and grease can be removed.

Vought Aeronautics Division, LTV Aerospace Corporation. This plant, located in Grand Prairie, discharges an estimated 1.5 mgd of wastewater into Mountain Creek. About 23 percent of the flow is domestic sewage, the remainder being industrial wastewater. Measurement of the combined effluent in 1969 indicated 11 mg/1 BOD, 70 mg/1 COD, and 26 mg/1 total suspended solids. The TWQB permit calls for an average flow of 1 mgd with BOD and SS not to exceed averages of 25 mg/1 each. While TWQB limitations on flow and SS concentration are somewhat exceeded, and COD concentration meets requirements, and expansion of treatment facilities for the industrial wastewater is currently underway.

Summary. Questionnaires are included in Appendix C for six of the industries discussed above. Wastewater from the seven industries represents a total average flow of about 4.0 mgd. Most of the wastes are inorganic. However, total organic pollution is estimated at about 2,950 lbs per day of BOD based on average conditions. The seven industries are listed in Table III-3 along with their wastewater characteristics.

All industries in the study area should abate pollution immediately. In incorporated areas enforcement is the responsibility of city governments. In unincorporated area enforcement is the responsibility of the counties. Local governments should take the initiative in pollution abatement.

It is recommended that all industries listed, with the exception of Nipak, Inc. pretreat their wastewaters as necessary such that they may be discharged to municipal or regional sewerage systems in accordance with appropriate sewer ordinances. It is recommended that Nipak Inc., treat its wastewaters or recover nutrients to eliminate a major source of nutrients which may cause eutrophication problems in the proposed Tennessee Colony Reservoir downstream from this plant. All industrial wastewater discharges must meet the requirements of the Texas Water Quality Board.

The expected wastewaters from future industries should be carefully considered as to composition and effect on the operation of existing sewerage facilities before permitting the industry to locate. Pretreatment at the industry may be necessary. The adoption of sewer ordinances would assist new industry and public officials in this regard.

SURFACE RUNOFF

Major sources of water pollution are municipal and industrial wastes, but these are not the only significant sources. As these concentrated sources of pollution are brought under control through construction of wastewater collection and treatment facilities, the remaining more diffuse and difficult to control sources may determine the water quality and the types of water use that can reasonably be maintained. These diffuse sources may be considered mainly as surface runoff reaching watercourses, which picks up polluting substances during its overland travel.

TABLE III-3. SUMMARY OF SIGNIFICANT INDUSTRIAL WASTEWATER DISCHARGE CHARACTERISTICS IN THE NCTCOG STUDY AREA

Node No.	Name of Industry	Average Wastewater Discharge (mgd)	Estimated Wastewater Quality [1] (lb/day)	Suspended Solids (lb/day)
5M-182	American Cyanamid Company	1.000	N/A [2]	N/A [3]
5K-183	American Manufacturing Company of Texas	0.216	250	4,500
5K-184	Fort Worth Refining Company	0.206	-	60
1A-239	Nipak, Inc.	0.630	160 [4]	20
1I-175	Procter & Gamble, Inc.	0.145	1,920	1,000
5M-181	Texas & Pacific - MP Railway Company	0.288	480	310
-	Vought Aeronautics Division, LTV	1.500	140	320
	Totals	3.985	2,950	6,210

Notes:

(1) Based on industrial waste questionnaires - Appendix C.
(2) Discharge permit restricts ammonia to 400 ppm maximum.
(3) Total solids run about 2,000 ppm.
(4) Considerable nitrogen in wastewater.
(5) Locations of industries shown on Figs. III-2, IV-1, and IV-2.

Surface runoff from both urban and rural areas can contribute significant amounts of organic and inorganic chemical pollutants as well as bacteria and viruses which may limit the usefulness of streams. Large livestock feeding operations may also contribute to pollution resulting from runoff. Nutrient contribution from various sources are discussed under Eutrophication in this Chapter. Based on analyses made by the Texas Water Development Board, an estimated average phosphate load of about 90,000 lb per day was carried in the Trinity River at Trinidad in 1968.

Land use practices may also affect the quality of the groundwater which reaches watercourses. The geology and climate of an area determines to a considerable extent the water quality that is attainable even with maximum control of waste discharges. The FWQA is presently conducting research at Tulsa, Oklahoma to develop the functional relationship between various land uses and analytical pollution measurements.

Urban Runoff. Dust and dirt from streets, material eroded from land and pavement, fecal material from domestic and other animals, and oily residues from vehicles contribute to the impairment of quality of runoff from urban areas. No studies have been made of the the quality of urban runoff in the North Central Texas Region, but a number of investigators have studied the quality of urban runoff in Texas and elsewhere. The most extensive data comes from the studies of Weibel and his colleagues who gaged and sampled runoff from a 27-acre residential and light commercial area in Cincinnati, Ohio from 1962 to 1964. Table III-4 summarizes the concentrations of various materials found in these samples. Tables III-5 summarizes their data on the bacteriological quality of the runoff from this area, and Table III-6 compares the pollution load from the urban runoff with that from sanitary sewage.

The estimates presented in Table III-6 are based upon estimated population density, sewage flow and strength and rainfall data for Cincinnati. Although hydrologic conditions in the Cincinnati and North Central Texas regions are not the same, it seems likely that the quality of urban runoff in the two regions would be similar. Total annual rainfall is similar in the two regions, both areas contain much clayey soil, and the streams in each area are highly turbid during storm runoff. The estimated annual BOD of storm runoff is comparable to that of the effluent from an efficient secondary wastewater treatment plant achieving better than 90 percent removal. Bacteriologically the stormwater runoff is too contaminated to meet generally accepted standards for recreational use. Nitrogen and phosphate concentrations are high enough to support a substantial algae population. The concentration of organic chlorine suggests that pesticides were present, but specific analyses for pesticides were not made.

A limited study of runoff from Waller Creek in Austin, Texas by Dinges and Cope in 1966 showed similar poor quality of the runoff from that urban area.

From these studies it is evident that surface runoff from urban areas constitutes a significant source of pollution. Its significance lies in the fact that it may equal the pollution load discharged to a stream from a secondary wastewater treatment plant.

Rural Runoff. Until very recently little attention had been directed to the contribution of rural surface runoff to water quality problems except for the suspended solids resulting from soil erosion. In the last few years, however, the

TABLE III-4. CONSTITUENT CONCENTRATIONS IN URBAN STORM WATER RUNOFF(1)

	Ranges of Discrete Samples	Storm Average
Turbidity (J.T.u.)	30-1,000	176
Color (C.u.)	10-460	87
pH	5.3-8.7	7.5
Alkalinity (mg/l)	10-210	59
Total hardness (as $CaCO_3$) (mg/l)	19-364	81
Chloride (mg/l)	3-428	12
SS (mg/l)	5-1,200	227
VSS (mg/l)	1-290	57
COD (mg/l)	20-610	111
BOD (mg/l)	1-173	17
N (mg/l)(2)	0.3-7.5	3.1
Inorganic N (mg/l)	0.1-3.4	1.0
Hydrolyzable PO_4 (mg/l)	0.02-7.3	1.1
Organic chlorine (mg/l)(3)	0.38-4.72	1.70

(1) From 27-acre residential, light-commercial area, Cincinnati, Ohio, July, 1962, through July, 1964. January and February, 1963, not included.
(2) Arithmetic sum of the four forms of nitrogen.
(3) From 11 storms, August, 1963, to February, 1964.

TABLE III-5. BACTERIAL COUNTS IN URBAN STORM WATER RUNOFF SAMPLES[1]

Bacterial Count	Counts Exceeded in Designated Per Cent of Samples, Per 100 ml		
	90%	50%	10%
Coliforms	2,900	58,000	460,000
Fecal coliforms	500	10,900	76,000
Fecal streptococci	4,900	20,500	110,000

Note:

(1) From a 27-acre residential, light-commercial area, Cincinnati, Ohio, 1962 and 1963.

TABLE III-6. COMPARISON OF URBAN STORM WATER RUNOFF LOADS WITH SANITARY SEWAGE LOADS(1)

	Sanitary Sewage Production		Urban Storm Water Runoff Loads as Per Cent of Sewage Load	
Constituent	lb/day/acre	lb/yr/acre	During Runoff	Annually
SS	1.5	540	2,400	160
COD	2.6	960	520	33
BOD	1.5	540	110	7
Total hydrolyzable phosphate (PO_4)	0.19	68	70	5
Total nitrogen (N)	0.23	82	200	14

Note:

(1) At Cincinnati, Ohio.

importance of fertilizers, pesticides and animal wastes as water pollutants has become generally recognized.

Water pollution problems in rural areas may result from the use of fertilizers and pesticides on farms. In 1964 the reported farm acreage within the 10-county North Central Texas Region was 3,904,777 acres (or 6,100 square miles) or about 76 percent of the entire area. Thirteen percent of the area (or 667,065 acres) of the region was fertilized with commercial fertilizers. Principal crops are cotton, wheat and grain sorghum. Pesticides are known to enter the Trinity River as discussed under Existing Water Quality.

Studies of runoff from rural areas within the North Central Texas area have not been made to date, but Weidner and his colleagues sampled runoff from several experimental watersheds at the U.S. Department of Agriculture Research Station at Coshocton, Ohio. They were able to study the effect of improved land management practices on the quality of the runoff from crop land in a corn, wheat, meadow rotation.

Prevailing practice involved straight row tillage across the slope and a low level of fertilizing soil was limed to pH 5.4 and fertilized with 5-20-20 fertilizer (150 lb per year per acre on corn and 100 lb per year per acre on wheat) and 4 tons per year per acre of manure. Improved practice involved contour tillage and high-level fertilizer rates. Soil was limed to pH 6.8, and fertilized with 5-20-20 fertilizer (360 lb per year per acre on corn and 180 lb per year per acre on wheat). Two hundred lb per year per acre of 0-20-20 fertilizers were applied on first-year meadow land. The improved practice reduced soil loss to 25 percent and runoff to 60 percent of that under prevailing practice. Calculated average annual quantities of various constituents in the runoff from these experimental areas are shown in Table III-7. The soil loss and the loss of other constituents was negligible from the land in meadow or well covered grass lands.

Most of the phosphate is associated with soil particles and remains with the soil in reservoir sediments. The nitrogen, on the other hand, is largely in soluble forms. Although improved land use practices can substantially reduce both soil loss and loss of fertilizer from crop lands, the concentration of phosphate and nitrogen in the runoff remains high enough to accelerate significantly the eutrophication of reservoirs.

Farm Animal Wastes. There were a reported 542,000 cattle and calves on farms in the NCTCOG region in 1961. The organic waste produced is estimated to be equivalent to that produced by a population of over five million people. No instances of water pollution from these sources have been reported. However, the trend toward confined feeding of cattle and swine has given rise to a serious problem in the handling of animal wastes from these operations in other areas.

The nitrogen pollution hazard created by large livestock feeding operations has been shown to emanate from three sources:

1. Nitrogen in surface runoff.

2. Nitrate in deep percolation from cattle feed lots.

3. Nitrogen loss by volatilization of nitrogenous gases into the atmosphere.

TABLE III-7. CALCULATED AVERAGE ANNUAL LOADS OF VARIOUS CONSTITUENTS FROM CROPLAND UNDER PREVAILING AND IMPROVED LAND USE PRACTICES*

Practice	Crop	Total Solids lb/acre	BOD lb/acre	COD lb/acre	PO_4 lb/acre	Total N lb/acre
Prevailing	Corn	13,200	120	1,300	27.7	237
Improved	Corn	3,660	27.5	480	8.4	88
Prevailing	Wheat	1,730	15.5	170	3.6	31
Improved	Wheat	480	3.7	64	1.1	11

*At Coshocton, Ohio

Hutchinson and Viets have studied ammonia absorption rates of water surfaces near feed lots. Results indicate that these rates are of such magnitudes that adsorption of ammonia volatilized from cattle feed lots contributes significantly to the nitrogen enrichment of surface waters in the vicinity of feed lots. The significance of farm animal wastes in relation to other wastewater sources is shown in Table III-8 presented in the discussion of eutrophication.

The Texas Water Quality Board has adopted regulations aimed at controlling waste discharges from commercial feed lot operations. Enforcement of these regulations should prevent most of the oxygen-demanding feed lot material from reaching watercourses. There will undoubtedly continue to be some contribution of nitrogen from them, however.

Conclusion. Large reductions in the quantities of nutrients discharged to watercourses from urban and rural runoff and from farm animal wastes appear to be needed if significant water quality improvement is to be achieved. Urban runoff and farm animal wastes, because they are relatively localized in occurrence, lend themselves more readily to some form of control. Rural runoff, on the other hand, is diffuse in nature, extending over most of the study area; and control is difficult.

The information now available on nitrates and phosphates in the Trinity River indicated significant concentrations do exist downstream from Dallas and Fort Worth. Any significant reduction in the discharge of these nutrients from rural areas, particularly those in agricultural use, would have to be accomplished by changes in fertilizing practice. Such changes would include bringing fertilizer application and plant (crop) requirements more closely into balance. Sound soil conservation practice coupled with educational programs is highly desirable in this regard. Close coordination between the NCTCOG, the State Soil and Water Conservation Board and the U.S. Soil Conservation Service appears warranted.

Another important effect of surface runoff is increased turbidity in the river resulting primarily from erosion of upstream land surfaces. If removals by sewage treatment plants are sufficient to make substantial reductions in nutrients discharged to the river and downstream reservoirs (such as Tennessee Colony Reservoir), eutrophication may be limited by light penetration in the turbid waters. In such a case turbidity may be said to have a beneficial effect even though, at the same time, reservoir storage capacity is reduced by resulting sedimentation.

REFERENCES

1. Agricultural Research Service, "Effects of Conservation Practices on Storm Runoff in the Texas Blackland Prairie", U.S. Department of Agriculture, Technical Bulletin No. 1406, Washington, D.C., Jan., 1970.

2. Dinges, W. R. and Cope, G., "Water Quality Survey, Waller Creek", Report to the Water Pollution Control Division, Texas State Department of Health, 1966.

3. Fruh, E. G., "Urban Effects on Quality of Stream Flow," Water Resources Symposium Number 2, University of Texas, Austin, Texas, 1969.

TABLE III-8. ESTIMATE OF NUTRIENT CONTRIBUTIONS FROM VARIOUS SOURCES

	NITROGEN		PHOSPHORUS	
	1,000,000 lbs/year	Usual Concentration in Discharge (mg/l)	1,000.000 lbs/year	Usual Concentration in Discharge (mg/l)
Domestic waste	1,100-1,600	18-20	200-500	3.5-9
Industrial waste	1,000	0-10,000	(2)	(2)
Rural runoff:				
Agricultural land	1,500-15,000	1-70	120-1,200	0.05-1.1
Nonagricultural land	400-1,900	0.1-0.5	150-750	0.04-0.2
Farm animal waste	1,000	(2)	(2)	(2)
Urban runoff	110-1,100	1-10	11-170	0.1-1.5
Rainfall(1)	30-590	0.1-2.0	3-9	0.01-0.03

Notes:

(1) Considers rainfall contributed directly to water surface.

(2) Insufficient data available to make estimate.

4. Galegar, W. C., "Pollution Effects in Rural Watersheds", Water Resources Symposium Number 2, University of Texas, 1969.

5. Hutchinson, G.L. and Viets, F. G., Jr., "Nitrogen Enrichment of Surface Water by Absorption of Ammonia Volatilized from Cattle Feed Lots", Science Vol. 166, 24 Oct., 1969.

6. Leopold, L. B., "Hydrology for Urban Land Planning - A Guidebook on the Hydrologic Effects of Urban Land Use", Geological Survey Circular 554, Washington, 1968.

7. Singer, S. F., "Where Nitrogen, Phosphorus Cause Pollution Problems", The American City, Dec., 1969.

8. Texas Water Development Board, Report 67, "Reconnaissance of the Chemical Quality of Surface Waters of the Trinity River Basin, Texas."

9. Weibel, S. R., Weidner, R. B., Christianson, A. G. and Anderson, R. J., "Characterization, Treatment and Disposal of Urban Stormwater", Advances in Water Pollution Research, Vol. 1, Water Pollution Control Federation, Washington, D.C., 1967.

10. Weidner, R.B., Christianson, A.G., Weibel, S.R. and Robeck, G.G., "Rural Runoff as a Factor in Stream Pollution", Journal WPCF, March, 1969.

EUTROPHICATION OF LAKES AND RESERVOIRS

DISCUSSION

In recent years, public attention has been called to the problem of eutrophication of natural and man-made lakes and the role of municipal and industrial wastes in causing the accelerated aging of lakes. Eutrophication may be defined as an increase in the nutrient content of water in a lake, which is indicated by a large quantity of algae and aquatic vegetation. Although it is part of the life cycle of lakes to become shallower, warmer, and more productive of plant life as sediments and plant nutrients accumulate, the activities of man can greatly accelerate the process and have done so in many lakes in Europe and the United States. As this occurs, the originally clear lake becomes turbid and growth of algae increases to the detriment of the quality of raw water supplies. Rooted and floating aquatic plants may present problems to boaters. The more desirable game fish are replaced by plant eating and scavenger fish. A lake that was once attractive and aesthetically pleasing may become a nuisance. Not only lakes but rivers and estuaries may suffer from fertilization problems, but lakes tend to suffer most because they provide the best opportunity for retention of nutrients, such as phosphates and nitrates.

Within the study area, reservoirs, lakes and rivers downstream from population centers and large industries may be expected to experience such problems. This condition may become particulary serious downstream from the Dallas-Fort Worth metropolitan area when the locks and dams on the Trinity River are constructed as part of the canalization project discussed under Low Flow Augmentation in this Chapter.

Of the many elements or nutrients needed for plant life those most commonly in short supply are phosphorus and nitrogen. These are the elements most prominent in the fertilizers used intentionally to stimulate crop products and they are also abundantly present in municipal wastewater even after so-called "complete" (conventional secondary) treatment. Industrial wastes may contribute significant amounts of these nutrients. Phosphorus and nitrogen are also present, but usually in much lower concentrations, in the runoff from urban and rural areas. The relative contribution of these nutrients from various sources will vary depending on local circumstances, but in many of the lakes which have become eutrophic, municipal and industrial wastewaters have been major contributors of nitrogen and phosphorus particularly phosphorus. The major increase in the use of nitrogen fertilizers, especially ammonia in crop production is causing increased nitrate concentrations in streams draining cultivated areas. Most of this nitrate enters from agricultural drains or with groundwater which provides the base flow of streams.

Hasler has indicated that low nitrogen levels do not guarantee freedom from excess algae growth because of the capability of some blue-green algae for nitrogen fixation when nitrogen is present in water in low concentrations. However, a recent report by the U.S. Agricultural Research Service indicated no significant stream pollution from nitrates resulted from the use of nitrogen fertilizers in the upper Rio Grande River. This finding is important inasmuch as crop fertilization has increased 35-to100-fold over a 30 year period.

Phosphorus concentrations however, show a fairly consistent relationship to eutrophication. Connel has conducted an extensive survey relating phosphorus concentration and algal growth for Texas streams and reservoirs. His sampling stations include locations on the Trinity River. In his report, he notes conditions of excessive algal growth on this river below Dallas and Fort Worth. His report concludes that in Texas rivers a concentration of phosphate between 0.3 mg/l and 1.0 mg/l leads to algal problems of varying frequency and seriousness. Those rivers with a concentration of phosphate in excess of 1.0 mg/l were observed to exhibit the objectionable characteristics of eutrophication and to contain excessive amounts of plant growth. Samples of Trinity River waters show considerably higher concentrations.

The results of a nationwide survey conducted by an AWWA Task Group have indicated that nitrogen and phosphorus in rural runoff appears to be greater than that contributed in domestic wastes. Agricultural runoff is the greatest single contributor of nitrogen and phosphorus to water supplies.

From Table III-8 it appears that about 5 billion lb of nitrogen and 1 billion lb of phosphorus reach our nation's water supplies every year. If these quantities were distributed throughout the 450,000 billion gallons of annual stream flow in the United States, the average concentration would be 1.35 mg/l and 0.27 mg/l for nitrogen and phosphorus, respectively, concentrations that are an order of magnitude above those that have frequently been cited as limiting for algal growth involved with eutrophication.

The data in Table III-8 also indicate that the greatest contribution of nitrogen and phosphorus to water is directly or indirectly a result of the activities of man. Increased population and more advanced technologic development suggest that such contributions will be even greater in the future.

In efforts to control or retard the eutrophication process, attention has focused particularly on reducing phosphorus contributions. This is due in part to the fact that any algae can supply their need for nitrogen by fixing atmospheric nitrogen and that sources such as rainfall can contribute significantly to the nitrogen content of lakes. Processes are now available and additional ones are being developed for removing phosphorus from municipal wastewaters. The cost of such processes, though substantial, is not beyond the reach of most communities where there is a need for reducing nutrient discharges. At present most plants do not attempt to remove phosphates, and in the study area practically all phosphates are considered to reach watercourses.

As discussed under surface runoff the estimated average phosphate load in the Trinity River at Trinidad was about 90,000 lb per day (for an average concentration of 1.4 mg/l). If it is assumed that no phosphates are removed from municipal sewage in the study area at present, the total daily phosphate contribution from this source would average about 40,000 lb per day (for a phosphate concentration of 20 mg/l). Thus, it is evident that municipal plant effluents in the North Central Texas region may constitute as much as half of the phosphate reaching the Trinity River system (if phosphate retention in lakes is disregarded). If 80 percent of the municipal phosphate load were removed in treatment processes, the portion reaching the River would constitute about 15 percent of the total load in the river.

The eutrophication process is not completely understood, and it is not possible to predict how successful a given control procedure will be in retarding or possibly reversing the process. There are four known ways to minimize lake eutrophication; limiting the fertility of water, utilizing food chains to utilize nutrients and improve the lakes, stimulating disease and parasites to kill off aquatic plants, and using toxic chemicals to kill algae.

Continuing research on each of these methods is needed to answer many unresolved questions. However, it is abundantly clear that uncontrolled discharges of nutrients in municipal and industrial wastes have been the most prominent factor in the accelerated aging of a number of lakes and that to wait until the problem has become acute before taking action may be false economy. Phosphate removal particularly should be considered for all major treatment plants in the study area at the earliest possible date.

REFERENCES

1. Bartsch, A.F., "Interior Steps up Fight against Water Polluters," Environmental Science and Technology, April,1970.

2. Connell, C.H., "Biological Nutrients in Texas Rivers and Reservoirs, Part I", University of Texas Medical Branch, Galveston, Texas, Aug., 1966.

3. Dugdale, V.A. and Dugdale, R.C., "Nitrogen Metabolism in Lakes, II. Role of Nitrogen Fixation in Sanctuary Lake, Pennsylvania", Limnology and Oceanog., 1961.

4. Fruh, E. G. and Moore, H. G., Jr., "Surplus Phosphorus Uptake by Micro-organisms - Algae", Center for Research in Water Resources, Austin,Texas, Jan., 1969.

5. Hall, M.W. and Engelbrecht, R.S., "Phosphate Removal-Past, Present, and Future," Water and Wastes Engineering, Aug., 1969.

6. Hasler, A. D.,"Eutrophication of Lakes by Domestic Drainage", Ecology,1947.

7. Mackenthun, K. M., "Nitrogen and Phosphorus in Water, an Annotated Selected Bibliography of Their Biological Effect", Dept. of Health, Education, and Welfare, U.S. Public Health Service, Pub. No. 1305, 1965.

8. Sawyer, C.N., and Ferullo, A. F., "Nitrogen Fixation in Natural Waters Under Controlled Laboratory Conditions", Algae and Metropolitan Wastes, Trans. 1960 Seminar, PHS, Robert A. Taft Sanitary Engineering Center, 1961.

9. Task Group Report, "Sources of Nitrogen and Phosphorus in Water Supplies", Journal AWWA, March, 1967.

LOW FLOW AUGMENTATION

It is generally recognized that the quality of water in the Trinity River between Fort Worth and Rosser is poor. Oxygen depletion in the stream caused by the bio-chemical oxidation of organic material results in the frequent occurrence of septic conditions and offensive odors. This condition of stream pollution is produced by large

quantities of municipal and industrial wastes being discharged from the Dallas and Fort Worth metropolitan areas, and is particularly critical during extended periods of time each year when natural stream flow is insufficient to provide proper dilution of the wastes, as discussed above under Existing Water Quality.

Three recognized methods of controlling the pollution in streams are: (1) in-plant control of industrial processes and waste discharges, (2) treatment of wastes discharged from industries and municipalities, and (3) stream flow regulation, or low flow augmentation. The first two methods are being practiced to some extent in the study area. The third method, however, is practiced only to a very limited extent because no appreciable storage has been allocated to this purpose in existing upstream reservoirs.

The Federal Water Pollution Control Act, Public Law 84-660 as amended, provided that consideration be given to the inclusion of storage space for regulation of stream flow for water quality control in any reservoir being planned by a Federal agency. However, storage space in all the existing reservoirs in the Upper Trinity River Basin has been allocated by existing permits and agreements to other purposes, such as municipal and industrial water supply, flood control and navigation. Waters allocated to navigation are presently being used on an interim basis, primarily for municipal purposes, until such time as the waters are needed for navigation of the Trinity River. Small releases of navigation water from Benbrook Reservoir have been made at times for improvement of water quality on the Clear Fork of the Trinity . These releases have not been of sufficient magnitude to have an appreciable effect on the quality of the main stem of the Trinity, however.

FLOOD CONTROL STORAGE

Approximately 1,289,000 acre-ft of regulated flood control storage is provided in five existing major reservoirs in the study area on streams tributary to the Trinity River. These include Benbrook Reservoir on the Clear Fork, with 170,350 acre-ft of flood control storage; Grapevine Reservoir on Denton Creek, with 238,250 acre-ft; Garza-Little Elm Reservoir on the Elm Fork, with 525,200 acre-ft; Lavon Reservoir on the East Fork, with 275,600 acre-ft; and Bardwell Reservoir on Waxahachie Creek, with 79,600 acre-ft. Planned reservoirs within the study area with flood control storage include Lakeview Reservoir on Mountain Creek, with 119,800 acre-ft allocated to flood control storage; Roanoke Reservoir on Denton Creek above Grapevine Reservoir, with 223,700 acre-ft; and Aubrey Reservoir on the Elm Fork above Garza-Little Elm Reservoir, with 257,300 acre-ft. At the time of construction of Roanoke and Aubrey Reservoirs the flood control storage in the respective downstream reservoirs, Grapevine and Garza-Little Elm, will be reallocated to provide increased conservation storage.

Flood control storage in the five existing reservoirs noted above is owned and operated by the Corps of Engineers. Storm runoff from the watershed above these reservoirs is stored in the flood control pools until such time that local runoff and discharge from other reservoirs have subsided sufficiently to permit the release of water from the flood control pools without undue flooding along the streams. The rate of release is controlled indirectly by the flow capacity of the stream. A critical location in the study area is near Rosser, where bank-full capacity is about 9,000 cfs. Channel capacity at Dallas is about 13,000 cfs. The time required to evacuate the flood control pools and make room for subsequent storm waters varies from a few days to several months, depending on the amount of storm runoff involved.

During the periods of flood flow and the subsequent periods of regulated releases, the concentration of organic wastes in the Trinity is lower than during low flow periods by virtue of the large volume of dilution water with a relatively high dissolved oxygen content as indicated on Fig. III-3. There are detrimental effects on water quality (aside from its heavy silt load) however, since the accompanying high river stages have an adverse effect on the operation of some of the sewage treatment plants along the river, particularly those constructed in low areas. Sewage is sometimes discharged with no more than primary treatment, or with no treatment at all. For example, at the Dallas sewage treatment plant a stream flow of about 5,000 cfs (river stage of about 24 ft, as measured at the Dallas Gage at Commerce Street) causes the secondary treatment units to be ineffective, and sewage is discharged after receiving only primary treatment. With a stream flow of about 7,000 cfs (river stage of 28 ft) the primary units at the White Rock Plant are ineffective and raw sewage is discharged to the river.

At the Fort Worth Village Creek Plant, primary treated sewage is discharged directly to the river at river stages greater than 8 ft above normal. The plant is shut down and raw sewage is overflowed to the river when the stage exceeds 32 ft above the normal level. Similar problems have been experienced at other plants as Arlington and Fort Worth Riverside.

During periods of regulated flood release, concentrations of BOD and dissolved oxygen are reported to be within acceptable limits because of detention; yet it is apparent that in absolute terms the accompanying discharge of improperly treated sewage imposes a heavy pollution load on the stream. Organic solids which settle out downstream exert a heavy oxygen demand, and with the recession of flow in the stream, can cause maximum oxygen depletion and septic conditions to prevail. If allowed to continue, the bypassing of improperly treated sewage in the study area will not only cause local pollution, but can hasten the eutrophication of Livingston Reservoir and the proposed Tennessee Colony Reservoir.

High river stages resulting from flood runoff from uncontrolled drainage areas and from subsequent regulated releases from flood control storage will continue to occur on the Trinity River. The proposed canalization of the Trinity will provide increased channel capacity (25,000 cfs at Dallas and 32,000 cfs at Rosser), thereby allowing more rapid disposal of storm runoff and reducing the duration of high river stages. It will not, however, negate the need for pumping facilities or other adequate means for securing proper treatment of sewage before its discharge into the watercourse.

TRINITY RIVER CANALIZATION

Canalization of the Trinity River for the 363-mile reach from the Houston Ship Channel to Fort Worth is included in the $1.37 billion program of development of the water and land resources of the Trinity River Basin planned by the U.S. Army Corps of Engineers. The plan of development is described in a report entitled, "Comprehensive Survey Report on Trinity River and Tributaries, Texas", dated June 1962. To date (1970) funds have been provided for the initial surveys. Provided in the plan are proposed means for satisfying the present and projected needs for water supply, water quality, flood protection, navigation, recreation, and fish and wildlife in the Trinity River basin. Projects recommended for authorization in the plan include a multiple-purpose channel from the Houston Ship Channel to Fort Worth for navigation and flood control purposes; four multiple-purpose reservoirs–Roanoke, Aubrey, Lakeview,

and Tennessee Colony; water quality control distribution facilities from Tennessee Colony Reservoir to the existing Benbrook Reservoir; and five local flood protection projects.

Under the Corps of Engineers plan for maintaining adequate flows in the Upper Trinity River, a pipeline would be constructed from the Tennessee Colony Reservoir to Benbrook Reservoir, which would transport a yearly average flow of 80 mgd. This water would be released from Benbrook Reservoir to satisfy flow augmentation needs, which are expected by the Corps to vary from 136 mgd in July to 29 mgd in January *during the early years* of development. The use of the storage capacity in Tennessee Colony Reservoir and the pipeline facilities initially allocated to low flow augmentation for water quality control would be converted to municipal and industrial use as the needs for water supply develop. It is anticipated that the 80 mgd yearly average would be available until about year 2020, and that by the year 2040 it would be completely transferred to municipal and industrial use. No plans are included to provide quality control water after that time.

The construction of Aubrey Reservoir above Garza-Little Elm Reservoir on the Elm Fork would increase the yield from above Garza-Little Elm by about 65 mgd. This amount would be made available initially for water quality control, but the amount would gradually decrease until it was all needed to meet municipal and industrial requirements. The Corps of Engineers report indicates that this is expected to occur by about 1985 or 1990.

It was envisioned in the Corps report that Aubrey would be constructed by about 1970. This has not come to pass, however, and though it is now before Congress for funding it is not expected that the project will be functional until about 1980. By that time there will be need for some of the increased yield for municipal and industrial purposes, and the amount of interim quality control water available will be reduced.

THE TEXAS WATER PLAN

The Texas Water Plan was prepared and published under that title in November 1968 by the Texas Water Development Board. The Water Plan is a guide for furnishing raw water, and other benefits to be derived from water development, necessary to meet the needs of Texans for all purposes throughout the State as the population grows and the economy expands. At a total estimated cost of almost $10 billion, it provides for the interbasin, and possibly the interstate, transportation of water from the points of surplus to the points of need. A constitutional amendment to authorize the Texas Water Development Board to issue $3.5 billion in bonds to accomplish the first phase of the Water Plan was defeated in September 1969.

With respect to water quality management in the Upper Trinity River Basin, the Texas Water Plan provides no storage for quality control water beyond that recommended in the Corps of Engineers plan. In addition, use of the Trinity River channel in the polluted reach between Fort Worth and Rosser is not planned for the interbasin transfer of water; therefore, it will not receive the benefit of flow augmentation which would result from such transfer.

EFFECTS ON TREATMENT REQUIREMENTS

In the Corps of Engineers report, estimates were made on stream loading and on the amounts of quality control water (low flow augmentation) required to meet acceptable standards. The assumption was made that sufficient treatment of wastes would be provided to remove 90 percent of the BOD and 15 percent of the total dissolved solids. It was further assumed that water for quality control would be required when the dissolved oxygen in the stream fell below 4.0 mg/1, or the total dissolved solids exceeded 1,000 mg/1. No consideration was given in that report to the removal of nitrogen or phosphorus. On the basis of these assumptions that report concluded that the waters of the Trinity River basin would not be degraded below the acceptable limit of total dissolved solids, if low flow augmentation were practiced. However, it was also concluded that organic pollution in the reach between Fort Worth and Tennessee Colony Reservoir site exceeds the assimilative capacity of the stream at present and would continue to do so in the future. The waters available for quality control through low flow augmentation in the basin upstream of this reach were not considered adequate to raise the dissolved oxygen level of the stream to acceptable standards. Nevertheless that report did indicate that a plan for maintaining the water quality of the basin could be developed through efficient use of available dilution water and utilization of advanced waste treatment technology to provide greater removals of BOD, phosphates and nitrogen. Advanced waste treatment methods are discussed in Chapter XI.

The Texas Water Plan indicates that low flow augmentation may help to bring water quality to levels that will satisfy water uses of the stream on an interim basis, but the highest technically and economically feasible treatment of wastes would still be needed.

It is apparent that with the anticipated continued growth of the Dallas-Fort Worth area, and with the extremely limited water quality control facilities planned by the Corps of Engineers, reuse of water must be practiced and the treatment of wastewaters to the highest practical degree will be necessary. Estimated low flow augmentation requirements to meet present water quality standards in the study area are discussed in Chapter X. In general, however, it appears that low flow augmentation alone would be an inadequate and costly response to the water quality requirements of the Upper Trinity River Basin.

EXTRANEOUS FLOWS

Extraneous flows are flows of relatively unpolluted ground or surface water, from any source other than domestic, commercial and industrial discharges, which by themselves are generally considered not to require treatment, and their entrance into sewers is therefore not wanted. Inevitably, however, such waters do enter sewerage systems and become part of the total sewage flow. Extraneous flows may, particularly during wet weather and periods of high ground water, constitute the major portion of flow in a sewerage system. For this reason extraneous flows have a significant bearing on the effectiveness of sewage collection and treatment systems. The problem of extraneous flows is common to most sewerage systems in the study area and elsewhere. For a sewerage system in which the discharge is treated before release to receiving waters, it is generally not economical or desirable to permit unlimited storm flows (or other extraneous flows) within the system. Therefore, it is well to design, inspect, and maintain systems to hold extraneous flows to a minimum. At the same time, design allowances must be made for the entrance of extraneous flow that it is impractical to prevent.

The TWQB recognizes that the relationship of sewer contents and water quality is two fold (1) infiltration of unpolluted water into sewer systems thus creating mor wastewaters, and (2) conversely, the exfiltration or seepage of polluted water out o sewer systems into ground water sources.

The Cities of Dallas and Fort Worth were recently directed by the TWQB to continu and intensify their present efforts to control and treat excessive infiltration and t bring the problem under control by 1975. Annual reports of all overflows must b submitted by each city.

The NCTCOG has applied for a Federal research and demonstration grant to develo data on infiltration and exfiltration problems in the North Central Texas region. Th project would provide for field tests of advanced methods of controlling storm wate infiltration into sanitary sewer systems. Construction of sewer systems in selected tes areas representative of a variety of area soil conditions would be included. Areas wil be selected to give reliable comparisons among present typical installations and nev demonstration installations. Special mobile equipment will sample all test location and make project evaluations under all weather conditions.

STORM FLOWS IN COMBINED SEWERS

Combined sewers are conduits either constructed for or used to receive and conve storm water runoff as well as sanitary sewage including infiltration and industria wastewaters. No combined sewers have been constructed to serve this dual functio within the study area, but many existing sewers do receive sufficient storm flows a times to become surcharged. In studies of combined sewer overflows in a number o large United States cities, it has been found that the liquid portion of sewag overflowing during a given year ranges from 3 to 4 percent of the annual sewag production. On the other hand, the solids portion of sewage which is discharge through combined sewer overflows, is estimated to range from 20 to 30 percent of th annual production because of the flushing action that occurs during storms.

INFILTRATION

Infiltration into sanitary sewers is considered to include those extraneous o unwanted flows sources. Entry of infiltration into sanitary sewer lines occurs becaus of broken sewer pipes, pipe joints, and manholes; improperly constructed pipe joint and manholes; and leakage through manhole covers from surface water. Infiltratio also enters a collection system through the connection of downspouts and surfac drains to the sanitary sewer system.

The quantity of infiltration varies with the type and tightness of construction, age c sewer, groundwater elevation and permeability of the surrounding soil. Infiltratio also varies from season to season as the groundwater table rises and falls; it bein usually lowest during prolonged dry periods in the summer and highest during th early spring.

Infiltration problems encountered in the North Central Texas region have been i part attributed to the expansion characteristics of the predominantly clay soil. Suc soils shrink and crack when they lose moisture and may also crack sewer pipe. In suc cases, the effect of a "French drain" may be realized when a rainstorm occurs.

Defective Y-branches are known to have contributed appreciable percentages o
infiltration. However, in most sewers except those containing large amou
cracked pipe, the bulk of the infiltration occurs through faulty joints. Joint leak
existing sewers is at least partially due to the types of jointing materials that hav
used in the past. Many sanitary sewers have been built with either cement-mor
hot-poured or cold installed bituminous joints. None of these jointing materia
proven entirely satisfactory because of the difficulty of making tight joints in th
and because tightness tends to decrease with time.

Leakage into existing sewerage systems tends to increase with age. Infiltratio
have been recorded (in other areas of the country) as high as 60,000 gpd per
sewer for entire systems below ground water, and up to 1,000,000 gpd per mile of
or more for short stretches.

Infiltration studies have been conducted in Dallas for many years. It was reporte
infiltration rates for sewers constructed in Dallas with asphaltic hot-poured
ranged as high as 72,000 gpd/in diameter/mile. The infiltration rate from all
constructed prior to 1957 was estimated at about 11,250 gpd/in diameter/mile
on length and size of street sewers. For sewers constructed between 1957 and 195
preformed compression joints the rate dropped to about 1,500 gpd/in diameter
It is evident that high infiltration rates may result from older sewers and that
rates can be markedly reduced through the use of modern jointing techniques.

A special infiltration study conducted in Garland in April, 1965 estimated infilt
rates to vary from about 1,200 to 5,400 gpd/in diameter/mile.

Inadequately installed house connection lines can be very important sour
excessive infiltration since these lines may often have a total length greater th
total length of the collecting sewers. Infiltration into house connections ha
measured and found to be as much as 90 percent of the total infiltration into a s
Adequate standards and control of construction are required to reduce infilt
from house connections.

Extraneous flows may enter sanitary sewer systems from other sources in addi
defective pipe joints as discussed above. Tests made of leakage through m
covers indicate that the rate of flow per manhole may range from 20 to as hig
gpm with a depth of one inch of water over the cover, depending upon the numb
size of holes in the cover. A few roof drains connected to the sanitary sewer c
overcharge smaller sewers. A rainfall of one inch per hour on 1,200 square feet
area, for example, would contribute flow at a rate of more than 12 gpm. Direct e
surface runoff into basements or drained crawl spaces, through window
areaways, basement garages or directly through foundation walls can result in f
extreme magnitude.

Expected quantities of flow from foundation drain connections may var
insignificant to prohibitive amounts and must be evaluated for each system. In
City, Missouri area foundation drain discharge is estimated to average 1.25 g
house.

UNDESIRABLE ASPECTS

Extraneous flows may effectively reduce the capacity of the pipe to carry the se for which it was designed. In heavy prolonged storms the extraneous flows ma exceed the sewer capacity that almost all the sanitary sewage is discharged direct the watercourses, rather than to the intercepting or trunk sewers. Pollutio watercourses is hence frequently severe for extensive periods during and after sto Disease-producing organisms abound in such polluted waters, severely limiting suitability of the waters for recreational and other uses. Such organisms, isolated identified in samples of overflow wastewater consisting of mixed sewage and s water, include pathogenic bacteria and viruses of types often found in raw san sewage. In addition, early portions of the overflow, particularly, contain concentrations of suspended solids and associated BOD. The sludge and debris w have settled or stranded in the sewer during low flows in the preceding dry-wea period are scoured from lateral branch and main sewers, and are carried to watercourse. Other nuisance-causing substances common to overflows include gr oil, floating solids and debris. The formation of sludge banks with attendant problems in the vicinity of outlets is a common result of such overflows.

Infiltration may lead to cave-ins and structural failures in sewers and paven resulting from soil washing into the sewer through leaky joints. Higher s maintenance costs result from soil deposits in the sewer and from root penetr into the leaky joints. The soil washed into the sewer may clog it.

The extraneous flow from surface or subsurface sources that enters the sewer sy results in an increase in pumping costs. Inasmuch as sewer capacities generally ex treatment plant capacities by substantial amounts the extraneous flow also may treatment upsets and overflows at the plant. Overflowing of sewage during high periods currently occurs in a number of systems in the study area including D Arlington, Fort Worth, Richardson and Garland.

An additional undesirable aspect of extraneous flow is that to handle this excess fl may become necessary to construct relief sewers and expand existing treat facilities. The City of Dallas is currently building storm water diversion and treat facilities to reduce untreated discharges to the Trinity River resulting overflowing sanitary sewers. These facilities are expected to achieve substantial sa over the construction of large interceptors and treatment plant expansions othe required to handle these flows.

Studies were made of the efficiencies of the Fort Worth-Riverside and Arli Sewage Treatment Plants during storm periods. It was found that even thoug strength of the sewage is weaker during storm conditions, the percent removal of under these conditions is less than the percent removal during normal dry we conditions.

The economic effect of the entrance of extraneous flow into sewerage systems course, to increase the cost of constructing, operating and maintaining sewer treatment facilities. Estimated total costs of infiltration in Garland based on annual cost data, updated to present costs, and capitalized at 6.5 percent amou about $13,000 per mile. Such a cost penalty demands that policies be develope implemented to reduce the entrance of unwanted flows.

RECOMMENDED POLICY

General. Efforts should be made to reduce infiltration and other extran
weather flows wherever possible in the existing sewers to permit them to
more effectively, to prevent treatment plant upsets and to reduce costs. N
should be built with materials and using techniques that best retard infiltr
sewers should be adequately inspected and repaired to keep infiltration rate
regulations should be enforced to insure that other extraneous wet weather
not introduced into the sewer system. *Reduction of infiltration* can result
useful lives for existing and recommended facilities and may be achieved by
and use of the following:

1. Appropriate high-quality construction materials.
2. Measures to protect sewers from hydrogen sulfide corrosion.
3. Preformed compression-type joints.
4. Modern construction techniques.
5. Adequate inspection procedures.
6. Regulation of house connections.

Construction Materials. Factors which should be considered in the se
materials for sewer construction are:

1. Flow characteristics - friction coefficient.
2. Life expectancy and use experience.
3. Resistance to scour.
4. Resistance to acids, alkalies, gases, solvents, etc.
5. Ease of handling and installation.
6. Strength to resist structural failure.
7. Type of joint - watertightness and ease of assembly.
8. Availability and ease of installation of fittings and connections.
9. Availability in sizes required.
10. Cost of materials, handling, and installation.

The character of sewage to be transported, presence of industrial wastes, co
conditions to be met or methods used, and such other local conditions
pertinent to material selection should be established to give proper consid
the foregoing factors.

Many materials are available for use in sewer construction including as
pipe (gravity and pressure), brick masonry, cast iron pipe, concrete (pla
pressure, precast pipe and monolithic), steel pipe (plain or corrugated)
pipe and several newer materials including plastics and ductile iron.

No one material is better than all the rest for all applications and e
advantages in certain installations. All the above materials come wi
provide acceptable watertightness if properly installed.

Corrosion Protection. Insofar as possible, sewerage systems should be
operated to be sulfide-free. When sulfide resulting in acid formati
prevented by design, ventilation, maintenance, chemical addition or con
entering the system, considerations must be given to corrosion-resist
vitrified clay or to protective linings of proven performance. Efforts
extend the life of sewer pipe materials may be either by the applicat
(corrosion) resistant barrier or by alterations to the composition of the p

To protect concrete and asbetos-cement pipe, coatings and linings of b
coal tar products, vinyl and epoxy resins and paints have been used with
The limitation on the success of such barriers, however, is the abilit
coating or lining completely free of pinholes. The seeping of acids throu
small as pinholes destroys the effectiveness of the lining. Plasticized pol
sheets, locked to large-size concrete pipe during manufacture, when pro
and sealed at joints, may be expected to have a 50 year life.

Alterations to the composition of concrete pipe include the use of T
which is somewhat more resistant to sulfate attack than Type I ceme
thickness (sacrificial concrete) sometimes is specified to increase pipe li
corrosive conditions develop. In reinforced concrete this extra thickne
added cover over the inner cage or reinforcing steel.

The use of dolomite or limestone aggregates in the concrete may redu
acid attack as much as five times when compared to granite aggre
dolomite or limestone aggregates possess these properties and test shou
the material to be used.

Cast-iron and ductile iron pipe is usually protected by a cement mortar
Steel pipe may be similarly protected, or plasticized polyvinyl chloride
cemented to the interior of the larger pipes.

Sufficient tests should be conducted or the results of existing tests shou
before linings are specified, in order that only linings of proven perfor
life (up to 50 years) are used.

Joints. The characteristics of a good sewer pipe joint include watertight
to root penetration, resistance to corrosion, a reasonable degree of
durability. In the past, jute and mortar joints were commonly used on
sanitary sewers they were too rigid, tended to shrink and crack an
watertight nor rootproof. Mortar joints were also susceptible to sulfid
in time destroyed the entire joint. Various types of bituminous mate
and are being used on many sanitary sewers.

AD-A036 540 CAMP DRESSER AND MCKEE BOSTON MASS F/G 13/2

UPPER TRINITY RIVER BASIN COMPREHENSIVE SEWERAGE PLAN. VOLUME I--ETC(U)

JUL 70

UNCLASSIFIED NL

2 OF 5

AD A036540

Factory-made (preformed) compression joints are being used successfully in limiting infiltration and root penetration on bell and spigot vitrified clay sewer pipe. The so called "O" ring joint, which is one type of compression joint, is easy to install and has given good results, not only on vitrified clay, but also on asbestos-cement, concrete and other types of pipe. Various designs of rubber type gaskets have been successfully used on sanitary sewers. Plain end pipe, either vitrified clay or concrete is coupled by a rubber sleeve secured to the pipe with clamping rings. Another type of compression joint consists of a bituminous impregnated filler which is available in strips and which can be compressed in a joint. Other types of modern joints that appear to be successful in limiting infiltration and root penetration are the chemical welded joints on plastic pipe and the welded joint on steel pipe. We recommend that all sewers constructed in the future be provided with compression-type (or welded) joints to reduce infiltration and provide a necessary degree of flexibility.

Construction Techniques. Modern effective construction techniques are essential to reducing infiltration into sewers.

Foundation for the pipe should be prepared either by shaping the trench bottom to fit the pipe barrel and the projecting joint elements, or by over-excavation and backfill with granular material. Very soft trench bottoms should be stabilized by the addition of a crushed rock or gravel bed. In areas of unequal settlement, timber cribbing, piles, or reinforced-concrete cradle may be necessary. Where water tables are high, dewatering is necessary while placing concrete.

Backfilling of the sewer trench is a very important consideration in sewer construction. The methods and equipment used in placing fill must be selected to prevent dislocation or damage to the pipe. The method of backfilling to be used varies with the width of the trench, the character of the materials excavated, the method of excavation, and the degree of compaction required. In improved streets, or streets programmed for immediate paving, a high degree of compaction should be required. In less important streets, or in sparsely inhabited subdivision where flexible macadam roadways are used, a more moderate specification for backfilling may be justified. Along outfall sewers, in open country, it may be sufficient to mound the trench and, after natural settlement,return to regrade the area. Compaction results should be determined in accordance with current AASHO (American Association of State Highway Officials) test procedure. Upon completion of backfill, steps should be taken to restore the surface fully to a condition at least equal to that which existed prior to the sewer construction.

Chapter IX of ASCE Manual of Engineering Practice No. 37 presents generally accepted criteria and methods of calculations for the determination of loads and supporting strength, and demonstrates generally accepted methods of combining these elements with the application of a factor of safety to produce a safe and economical design. Methods are also presented for the determination of probable maximum loads due to gravity earth forces and for both static and moving superimposed loads. These methods, where so noted, are applicable to rigid and flexible conduits in the most common installation conditions: in trench, in natural ground, in embankment, and in tunnel.

Inspection and Maintenance. Accompanying adequate sewer design, there should be provision for adequate inspection to insure proper construction practice. Besides overseeing construction procedure, construction inspection should include

infiltration and/or exfiltration tests on the newly completed sewer. Under soil and groundwater conditions that insure a groundwater table at a suitable elevation above the top of the sewer pipe after the completion of construction, an infiltration test is sufficient; where the ground water table is below the sewer invert after the completion of construction, an exfiltration test is indicated. Existing sewers should be regularly inspected for leaks. Photographic or television inspection, accomplished by passing a camera along the interior of a sewer, readily reveals and locates leaks and pipe failures. Such a system is used by Dallas.

The repair of major leaks and pipe failures may require excavation to expose the problem area. The repair of most smaller leaks discovered in the inspection process may be accomplished using grout or chemical sealants which may be applied from within the pipe thus eliminating the cost of excavation and attendant problems.

Regulations of House Connections. Proper design and construction of trunk sewers and street laterals will reduce infiltration through cracked pipes,defective joints, leaking manholes, and surface-water entrance through manhole covers etc.; yet, design and construction of public sewers cannot eliminate infiltration from faulty house connections, illegal connections, or other defects on private property unless adequate control is exercised in this area also. Control on private property must be exercised through regulations or ordinances enforced by the appropriate political subdivisions.

Because careful inspection and good workmanship in private property construction usually are more difficult to achieve than adequate construction and inspection of public sewers, some cities such as Dallas require pressure tests on house connections. It is clear that there should be suitable public control, requiring high quality specifications and construction practices, for house sewers because of the economic importance of the infiltration provision in the capacity of public sewers.

The regulations for installation of building sewer connections (usually from the property line to the building) are commonly included in the municipality's plumbing ordinance. This ordinance should set forth the procedures, materials, methods of testing and permit and inspection requirements, and if properly structured and enforced it will result in adequate control of infiltration into the system.

The Cities of Dallas and Fort Worth have plumbing ordinances which may be used as a guide by those municipalities that are in the process of preparing their own or may prepare their own in the future. In addition, the planned NCTCOG study of infiltration and exfiltration problems in the North Central Texas Region is intended to yield model building codes and ordinances, subdivision regulations for sanitary sewer construction, specifications for materials, and testing procedures.

DESIGN ALLOWANCE FOR INFILTRATION

Although infiltration control reduces operation and maintenance costs, and definitely provides greater control of pollution of watercourses, it is not economically feasible to eliminate infiltration entirely. Costs for infiltration control involve expense to private parties due to control regulations. Furthermore, since compliance with regulations prohibiting surface drain and foundation drain connections may increase yard grading and building construction costs, it must be anticipated that there may be resistance to such regulations. Construction from now on should be regulated to a much greater extent than that practiced when the systems were begun.

The designer must evaluate the prevailing conditions and make allowances for such amounts of manhole leakage, roof water, and surface runoff as in his judgement will be unavoidable under the probable enforcement conditions for the specific area under design. Hence there is a point of balance for each sewer system beyond which the cost of extraneous flow will not be offset by equal savings in the cost of sewers and treatment facilities and beyond which statutory regulations are of doubtful value. The points of balance for various systems in the study area vary, but infiltration allowances have been developed for estimating purposes based on available information as discussed in Chapter V.

CONCLUSIONS

The entrance of extraneous or unwanted flows into sewerage systems results in overloaded sewers and treatment plants, overflows of mixed sewage and storm water to watercourses, and high costs to provide additional capacity in new facilities. It is desirable from each of these standpoints to reduce the entrance of extraneous surface and ground waters into sewerage systems to the maximum extent possible with modern methods of construction, available materials, maintenance and repair procedures, inspection and ordinances. The TWQB requires that Dallas and Fort Worth control and treat excessive infiltration within five years.

The control of infiltration by means of enforceable plumbing ordinances or codes for building sewer connection work, and by proper design and inspection of all sewer pipe installation, should be the goal of all municipalities. It behooves each municipality to adopt and enforce satisfactory measures in this regard. Only in this way can city, state and federal funds for sewerage system construction be expended with maximum long term economic benefits. Improvement of water quality in the region's lakes and streams will be assisted by the control and/or treatment of overflows resulting from excessive infiltration.

REFERENCES

1. Black & Veatch, "Report on Sanitary Sewerage Facilities for Dallas, Texas", Kansas City, Missouri, 1960.

2. Camp, T.R., "Water and Its Impurities", Reinhold, New York, New York, 1963.

3. Graeser, H.J. "Dallas Has Modern Approach to Sewer Installation," Water and Sewage Works, Sept., 1969.

4. Johnson, R.E.L., "Development of Sanitary Sewer Design Criteria for the City of Houston, Texas," Journal WPCF, Nov., 1965.

5. Rawn, A.M., "What Cost Leaking Manhole?", Waterworks and Sewerage, 84, 12, 1937.

6. Santry, I.W., "Sewerage Development Plan Prepared for the City of Garland, Texas," Dallas, Texas, Nov., 1965.

7. Swab, B.H., "The Effect of Hydrogen Sulfide on Concrete Structures," Camp, Dresser & McKee, Boston, Massachusetts, 1961.

8. Tolf, R.D., "Foundation Footing Drains in Separate Sanitary Sewers," Presented at Annual Meeting Central States Water Poll. Control Assn., 1961.

9. Velzy, C. R., and Sprague, J. M. , "Infiltration Specifications and Tests," Sewage and Industrial Wastes, Feb. 1955.

10. Weller, L. W., and Nelson, M. K., "A Study of Stormwater Infiltration into Sanitary Sewers," Journal WPCF June, 1963.

11. Weller L.W., and Nelson, M.K., "Diversion and Treatment of Extraneous Flows in Sanitary Sewers," Journal WPCF March, 1965.

12. Western Company, The, "Improved Sealants for Infiltration Control", FWPCA Publication WP-20-18, June, 1969.

13. Western Company, The, "Polymers for Sewer Flow Control," FWPCA Publication WP-20-22, Aug., 1969.

14. WPCF Manual of Practice No. 9 (ASCE Manual of Engineering Practice No. 37). "Design and Construction of Sanitary and Storm Sewers," 1969.

CHAPTER IV

EXISTING SEWERAGE FACILITIES

GENERAL

To provide a sound basis on which to make recommendations for sewerage facilities required to handle future sewage flows and loads, it is necessary to determine the capacities and usefulness of existing facilities. In 1968, an inventory of all existing sewage treatment plants in the North Central Texas region was made for the NCTCOG by Forrest and Cotton, Inc., and Freese, Nichols and Endress. The total number of municipal sewage treatment plants in the study area at present is 132. Pertinent data on these plants are shown in Table IV-1.

For this study, questionnaires on 25 major wastewater treatment plants have been completed, which contain pertinent up-to-date information on the plants. The questionnaires are presented in Appendix B, and a brief discussion of each of 31 major plants is presented hereinafter.

An inventory of all existing major trunk sewers in the study area was made as part of this study. Data pertaining to the capacities and sizes of the various trunk sewers are tabulated in Appendix D. In addition, an inventory of septic tank systems in the study area was made as part of this study and as presented herein.

All existing sewage treatment plants and major trunk sewers in the study area are shown on Fig. IV-1 and IV-2, appended to this volume.

The adequacy of existing sewage treatment facilities to handle future requirements is discussed in Chapter VIII. The adequacy of existing major trunk sewers is reflected in the requirements for relief interceptors as proposed in Chapters IX and X.

EXISTING MAJOR TRUNK SEWERS

Existing major trunk sewers listed in Appendix D and shown on Fig. IV-1 and IV-2 are those which are considered to have significance to a regional sewerage plan. Such a plan involves the collection and treatment of sewage from more than one population center or node. A number of existing trunk sewers which are so located as to lend themselves conveniently to a regional sewage transmission system are considered suitable for utilization. The criteria used for deciding which sewers qualify as "major trunk sewers" consists of any one of the following:

1. The sewer is an influent line to one of the major treatment plants.

2. If only one city is served by the sewer, it is considered as a trunk sewer to the point upstream where it receives flow from a number of branch and/or collecting sewers.

3. If more than one city is served, it is considered as a trunk sewer upstream to the last community served.

TABLE IV-1. CHARACTERISTICS OF EXISTING SEWAGE TREATMENT PLANTS(1)

Node No.	Location	Year Built	Year of Latest Expansion	Design Capacity (mgd)	1968(2) Flow (mgd)	1968(2) Effluent BOD (mg/l)	1968(2) Effluent SS (mg/l)	Remarks
TRINITY RIVER - WATERSHED 1								
1A-211	Kerens			0.14	0.09	55	56	
1B-92	Sonoma (Ennis System)	1951		0.42	0.31	40	35	
1C-90	*Nickerson & Nickerson, Inc. (Palmer)*			-	0.003	-	-	
1C-91	Palmer			0.04	0.04	-	-	
1D-145	Wilmer			0.09	0.06	30	128	
1D-161	TRA Ten Mile Creek	1970		7.00	-	-	-	Under construction
1E-147	Kleberg			0.50	0.22e(3)	30	46	
1E-149	Balch Springs (Dallas - Hickory Tree WCID #6)	1961		0.60	0.25	-	-	
1E-150	*Seagoville Fed. Corr. Institute*			0.30	0.08	-	-	To be phased out
1F-146	Dallas - South Side	1966		7.00	4.00e	40	123	
1G-143	Hutchins			0.18	0.10e	20	39	
1H-66	Richardson	1955	1961	1.54	1.60	12	17	
1I-175	Dallas - White Rock	1953	1963	54.00	67.20e	48	46	
1I-176	Dallas	1917	1951	36.00	33.00e	39	41	
	Subtotal			107.81	106.95e			
CEDAR CREEK - WATERSHED 2								
2A-202	Mabank			0.05	0.05e	-	-	
2A-203	Malakoff			0.19	0.10	30	170	
2A-204	Athens - North			0.71	0.25	37	61	
2A-205	Athens - West			0.75	0.30	21	33	
2A-208	Trinidad			0.13	0.06e	19	27	
2B-191	Wills Point			0.21	0.22e	61	90	
2C-192	Terrell - Kings Creek	1934	1955	0.96	1.60	44	135	New plant planned
2C-193	Terrell - Bachelor Creek	1963		0.40	0.10e	14	37	
2C-196	Kaufman			0.64	0.41	60	48	
2C-199	Kemp			0.10	0.05e	33	39	
	Subtotal			4.14	3.14e			
EAST FORK TRINITY RIVER - WATERSHED 3								
3A-58	Seagoville			0.34	0.19e	80	52	
3A-61	Crandall			0.07	0.04e	38	26	
3B-15	Farmersville			0.60	0.19e	45	34	
3B-16	Rockwall	1957		0.16	0.14e	85	20	Being expanded to 0.60 mgd
3B-51	Forney			0.28	0.20e	-	-	
3C-54	Mesquite	1959	1964	7.00	4.80	18	24	
3D-23	Garland - Duck Creek	1962		10.00	9.80	27	36	Expansion planned to 30 mgd
3E-26	Plano	1959	1965	1.85	1.50	24	38	
3E-40	Garland - Rowlett Creek			2.00	2.70	27	45	Expansion planned to 6.00 mgd
3G-34	Wylie			0.64	0.13e	-	-	
3H-1	Anna			-	0.04e	-	-	
3H-3	McKinney - North			0.50	0.25	18	16	
3H-24	McKinney - South			0.50	1.25	16.5	16	
3I-0	Van Alstyne			-	0.21e	34	55	
3I-5	Princeton			0.06	0.07e	33	117	
3J-8	Blue Ridge			0.08	0.02e	-	-	
3J-7	Tom Bean			0.04	0.03e	-	-	
3J-11	Trenton			-	0.02e	21	62	
3J-14	Leonard			0.17	0.07e	13	32	
	Subtotal			24.29	21.65e			
ELM FORK TRINITY RIVER - WATERSHED 4								
4A-81	Lewisville	1958	1969	1.76	0.60	30	24	
4A-166	TRA Central	1959		30.00	13.60	23	53	
4B-149	J. W. Helton (Justin)			-	-	-	-	
4B-150	Justin			0.05	0.05	3	38	
4B-151	Roanoke			0.07	0.04	-	-	
4B-156	Grapevine			0.24	0.29	15	30	
4B-170	Green Acres Estates			-	-	-	-	
4C-50	Muenster			0.10	0.14	40	151	
4C-54	Lindsay			-	0.02	-	-	
4C-55	Gainesville			1.50	1.39	48	50	
4C-70A	Lake Dallas			0.20	0.50	20	20	
4C-71	Denton	1963	1970	6.00	2.60	15	31	Being expanded
4C-206	Prosper			0.04	0.02	16	157	
4C-209	Frisco			0.25	0.07	13	10	
4D-100	Krum			0.08	0.03	-	-	
4E-10	Sanger	1927		0.12	0.11	136	85	
4E-11	Nickerson & Nickerson, Inc. (Sanger)			-	0.003	-	-	
4F-60	Pilot Point			0.09	0.11	-	-	
4F-64	Aubrey			0.07	0.04	40	126	
4F-200	Gunter			0.03	0.05	50	82	
4F-204	Celina			0.01	0.08	23	85	
4G-213	Collinsville			0.06	0.06	23	90	
4G-214	Tioga			0.06	0.04	35	25	
	Subtotal			40.54	20.96			
WEST FORK TRINITY RIVER - WATERSHED 5								
5A-20	Keller (No. Tarrant Co. M.W.D.)	1960	-	0.21	-	-	-	
5A-24	Grapevine			0.20	-	-	-	Under construction
5A-60	Greenview Addition	1970	-	0.04	-	-	-	
5B-170	Green Valley Mobile Home Park			-	-	-	-	
5C-1	Venus			0.02	0.03	55	163	
5C-500	Midlothian			0.90	0.10	25	44	
5D-214	Mansfield			0.32	0.20	-	-	
5E-195	Arlington	1957	1970	6.50	5.41	52	45	Under construction
5F-184	Euless - West			0.50	1.50e	-	-	To be phased out
5F-188	Euless - East			0.50	1.00e	-	-	To be phased out

TABLE IV-1. CHARACTERISTICS OF EXISTING SEWAGE TREATMENT PLANTS[1] (Continued)

Node No.	Location	Year Built	Year of Latest Expansion	Design Capacity (mgd)	1968[2] Flow (mgd)	1968[2] Effluent BOD (mg/l)	Effluent SS (mg/l)	Remarks
WEST FORK TRINITY RIVER - WATERSHED 5 (Continued)								
5F-189	Greater Southwest			0.50	0.04	-	-	Being phased out
5G-130	Burleson			0.60	0.26	50	46	
5G-132	Crowley			-	0.08	-	-	
5G-133	Sunny Acres Mobile Home Park			-	-	-	-	
5G-136	Everman			1.12	0.19	8	32	
5G-137	Kennedale			0.20	0.14	6	10	
5G-138	Forest Hill			0.70	0.70	21	10	
5G-180	Fort Worth - Village Creek	1956	1970	45.00	26.70	35	48	Further expansion planned
5H-141	Banfield Mobile Home Park			0.01	-	-	-	
5H-143	Royal Coach Mobile Home Park			0.25	-	-	-	
5H-145	L & M Mobile Home Park			0.01	-	-	-	
5H-150	Treetop South Mobile Home Park			0.10	-	-	-	
5H-153	Tumbleweed Mobile Home Park			0.06	-	-	-	
5H-156	Wilson			0.004	-	-	-	
5H-159	Poly-Webb Mobile Home Park			-	-	-	-	
5J-17	Keller Mobile Home Park			0.001	-	-	-	
5J-107	Haltom City			1.20	1.62	32	35	(phased out-1970)
5J-112	Richland Hills (TCWSC #2)			1.10	0.46	145	156	
5M-101	Fort Worth - Riverside	1924	1953	30.00	25.40	28	35	To be phased out
5M-172	TCWSC #1 (Highway 820)			1.39	-	-	-	
5Q-71	Benbrook			0.29	0.28	8	234	
5Q-72	St. Francis Village			0.05	0.05	20	34	
5Q-73	Weatherford			1.00	0.75	24	12	
5Q-76	Aledo			0.02	0.01	-	-	
5S-18	Chico			0.03	0.05	35	42	
5S-19	Bridgeport			0.39	0.04	60	40	
5S-23	Runaway Bay			0.01	0.003	-	-	
5S-38	Jacksboro			0.34	0.31	26	39	
5S-39	Decatur			0.32	0.21	-	-	
5S-46	Boyd			0.12	0.05	44	84	
5S-51	Rhome			-	0.005	-	-	
5S-52	Springtown			0.12	0.14	85	-	
5S-59	Lakeside			0.03	0.10	-	-	Under construction
5S-175	Azle (TCWSC)			-	-	-	-	
5T-1	Bowie - South			0.42	0.10	15	16	
5T-28	Bowie - East			0.37	0.30	40	50	
5T-11	Alvord			0.07	0.06	19	192	
	Subtotal			95.02e	66.29e			
NOLANDS RIVER - WATERSHED 8								
8A-1	Johnson Co. FWSD #1 (Joshua)			-	0.05	-	-	
8A-2	Cleburne			2.40	1.36	86	50	
8A-3	Godley 8A-3			-	0.01	-	-	
	Subtotal			2.40	1.42			
CHAMBERS CREEK - WATERSHED 10								
10A-80	Alvarado			0.08	0.09	27	29	
10A-81	Maypearl			0.05	0.03e	50	47	
10A-82	Keene			-	0.13	-	-	
10A-83	Grandview			0.20	0.08e	23	28	
10A-84	Italy			-	0.09e	-	-	
10A-85	Avalon W.S.& S. Corp. (Italy)			-	-	-	-	
10A-86	Milford			0.12	0.05e	-	-	
10A-97	Corsicana[4]			2.77	2.62	-	-	Outside study area
10A-99	Forreston	1970		0.03	-	-	-	Under construction
10B-89	Waxahachie	1951	1961	0.96	0.95	65	30	
10B-90	Wayside Mobile Home Park (Waxahachie)			-	-	-	-	
10B-544	Bardwell	1970		-	-	-	-	Under construction
	Subtotal			1.44	1.29e			
CUMMINS CREEK - WATERSHED 11								
11A-94	Ennis (Oak Grove)	1961		0.60	0.75	20.5	43	
SABINE RIVER - WATERSHED 12								
12A-10	Fate			-	-	-	-	
12A-18	Royse City	1970		0.26	-	-	-	New plant under construction
12A-501	Josephine	1969		0.10	-	-	-	
	Subtotal			0.36				

Notes:

(1) Based on the questionnaires for major Wastewater Treatment Plants, Appendix B, data from TSDH and TWQB, and on "An Inventory of Water Related Systems and Facilities," prepared for NCTCOG, April, 1968.

(2) Or adjacent year.

(3) e - estimated.

(4) Data for Corsicana represents the total of both existing plants. Corsicana is outside the study area, and its data are not included in the watershed subtotals.

The trunk sewers shown on Fig. IV-1 and IV-2 are designated by means of trunk sewer numbers shown within ellipses. These numbers are keyed to the tabulation in Appendix D and the numerical order of sewer reaches indicated in the tabulation proceeds upstream from the downstream end of the sewer. Trunk sewer data shown in the Appendix include slope, size and estimated flowing full capacity. Plans for the major existing trunks were utilized to provide the data shown, and no field surveys were conducted specifically for this report.

As indicated in Appendix D, the major trunk sewers listed range in size up to 96-in in diameter for gravity lines and have a total length of about 335 miles.

EXISTING MAJOR TREATMENT PLANTS

As indicated above, pertinent data for 25 existing major sewage treatment plants within the North Texas Central region are presented in questionnaires in Appendix B, and these 25 plus an additional six plants are described briefly below. Major plants are considered to be those which because of their size, location, and other factors appear to have some potential for carrying future sewage flows anticipated in a regional sewerage plan.The remaining 101plants in the study area are considered to be either too small or too remotely located from other plants and population centers to have regional significance.

It is significant that some of the major plants discharge their effluents into nearby water supply reservoirs. A comparison of the performance of these plants with State discharge permit requirements, is made in Chapter VIII.

Most of the major plants have secondary treatment facilities consisting either of the activated sludge process or, more commonly, the trickling filter process. Sludge digestion and the dewatering of sludge on drying beds are common practices. Many plants are located in river flood plain areas and experience operational difficulties during high river stages.

TRA-TEN MILE CREEK PLANT (1D-161)

The Ten Mile Creek Sewerage Plant is a regional plant serving the Cities of Lancaster, Ferris, DeSoto, Duncanville and Cedar Hill. This treatment plant and its tributary trunk sewers are under construction at the present time. It will be an activated sludge plant with a rated capacity of 7.0 mgd. Sewage will reach the plant by gravity where it will be pumped and then treated by means of primary clarification, extended aeration, final clarification, chlorination, and discharge to Ten Mile Creek, thence to the Trinity River. Sludge will be thickened, anaerobically digested and centrifuged.

DALLAS PLANTS

The City of Dallas operates three major wastewater treatment plants; the Dallas Plant, White Rock Plant, and South Side Treatment Plant. The South Side Plant is located some distance downstream and on the opposite side of the Trinity River from the Dallas and White Rock Plants. The Dallas and White Rock Plants are located on the same site, with a total rated capacity of 90 mgd at the present time. Both of these plants experience difficulties during periods of high river stage, resulting in the

overflowing of some sewage directly into the Trinity River and the occasional inundation of sludge lagoons. Effluent chlorination is not practiced at either the Dallas Plant and chlorination facilities are being installed in the White Rock Plant.

South Side Plant (1F-146). This plant has a rated capacity of 7.0 mgd. Screened raw sewage is fed into two large lagoons which are arranged in series. These lagoons have a total surface area of about 135 acres and the sewage is treated by oxidation before discharge to the Trinity River. A conventional sewage treatment plant is planned at this site, and a large site (approximately 640 acres) is available for plant expansion.

Dallas-White Rock Plants (1I-175, 1I-176). The Dallas Plant has a capacity of 36 mgd, and the White Rock Plant has a capacity of 54 mgd. Both plants provide screening, grit removal, primary sedimentation, biological treatment with trickling filters, final sedimentation, and separate anaerobic digestion of sludge. Effluents are discharged to the main stem of the Trinity River.

Digested sludge is discharged to sludge lagoons or "tertiary digesters." The Dallas Plant differs from the White Rock Plant by utilizing Imhoff tanks and single-stage, low-rate trickling filters. The White Rock Plant has no Imhoff tanks and utilizes two-stage, high-rate trickling filters. The Imhoff tanks at the Dallas Plant are now being converted to plain sedimentation tanks, and planning is now under way to increase the capacity of the combined Dallas and White Rock Plants from 90 mgd to 125 mgd.

The City of Dallas is operating a water reclamation research demonstration plant for studying improved methods of wastewater treatment and for conducting research in demonstration projects for wastewater reclamation and polishing processes. The demonstration plant, known as the Dallas Water Reclamation Research Center, was completed in 1969 under a grant from the Federal Water Pollution Control Adminstration, (now the FWQA) and it has a capacity of about 1 mgd. Research into chemical precipitation for nutrient removal is being carried out at this plant under a research grant from the FWQA.

RICHARDSON PLANT (1H-66)

The Richardson-Floyd Branch Treatment Plant has a rated capacity of 1.54 mgd and is a trickling filter type plant. Raw sewage reaches the plant by gravity where it is screened and lifted into clarigesters for sedimentation and digestion, trickling filters and final clarifiers. Continuous chlorination is practiced using the final clarifier as a chlorine contact chamber. Effluent is discharged into Floyd Branch and thence into White Rock Creek. Digested sludge is dewatered on sludge drying beds. Research into reuse of the treated effluent is being carried out at this plant under the auspices of the FWQA.

ATHENS PLANTS

The City of Athens is served by two plants known as the North Side and the West Side Treatment Plants. Together these plants have a combined capacity of 1.46 mgd. No chlorination of the effluents is provided at these plants.

North Side Plant (2A-204). The Athens-North Treatment Plant has a rated capacity of

0.71 mgd and is a trickling filter type plant. Flow enters the plant by gravity where it is lifted, screened, and passed through an Imhoff tank and a trickling filter before being discharged to an oxidation pond and thence into One Mile Creek.

West Side Plant (2A-205). The Athens-West Treatment Plant has a rated capacity of 0.75 mgd and is also a trickling filter type plant. The plant process is essentially the same as that for the Athens-North Plant except that instead of an Imhoff tank, more modern clarigester type units are utilized. Sludge is disposed of on sludge drying beds. Unchlorinated effluent is discharged into Walnut Creek and thence into Cedar Creek.

TERRELL PLANTS

The City of Terrell is served by two treatment plants known as the Kings Creek Plant and the Bachelor Creek Plants. These plants together have a combined capacity of 1.36 mgd, and no effluent chlorination is practiced at either plant.

The City of Terrell is currently planning the construction of a new sewage treatment plant downstream on Kings Creek. It is expected that this construction will be advertised in early summer of 1970. The new plant will have a capacity of 3.0 mgd and be a two-stage trickling filter type plant capable of ultimate expansion to about 18 mgd. The existing Kings Creek Treatment Plant will not be abandoned completely but will be utilized to pretreat industrial wastewaters before they are sent to the new plant.

Kings Creek Plant (2C-192). The Terrell-Kings Creek Treatment Plant is a trickling filter type plant with a rated capacity of about 1.0 mgd. It consists of a primary clarifer, trickling filter, and final clarifier. Present sewage flow is about 2.1 mgd. Sludge is digested anaerobically and dried on beds. The unchlorinated effluent is discharged into Kings Creek hence to Cedar Creek Reservoir.

Bachelor Creek Plant (2C-193). The Terrell-Bachelor Creek Treatment Plant is an extended aeration type plant with a rated capacity of 0.4 mgd. This plant consists of a single unit which includes facilities for screening, clarification, aeration, aerobic digestion and sludge reaeration. Aerobically digested sludge is withdrawn to sludge drying beds and the unchlorinated effluent is discharged into Bachelor Creek and thence to Kings Creek.

KAUFMAN PLANT (2C-196)

The Kaufman Treatment Plant is a trickling filter type plant with a rated capacity of 0.64 mgd. Raw sewage is pumped up into clarigesters and then is passed through a trickling filter and to a final clarifier before discharge into Kings Creek without chlorination. Digested sludge is dried on sludge drying beds.

ROCKWALL PLANT (3B-16)

The Rockwall Treatment Plant presently is a clarigester plant providing primary treatment only with a rated capacity of about 0.16 mgd. Plant expansion is expected within the next two years to a capacity of 0.6 mgd. The expanded plant will be an extended aeration type plant utilizing primary clarification, an oxidation ditch, final clarification and chlorine contact. Effluent from the plant is discharged into Squabble Creek and thence into Lake Ray Hubbard.

MESQUITE PLANT (3C-54)

The Mesquite Treatment Plant is a trickling filter type plant with a present rated capacity of 7.0 mgd. The plant treatment units include primary clarifiers, high rate and standard-rate trickling filters, primary and secondary digesters and final clarifiers. Effluent is discharged to oxidation ponds before being discharged into Mesquite Creek and thence into the East Fork of the Trinity River. Final clarified sludge may be digested aerobically and dewatered on sludge beds or returned for anaerobic digestion with the primary sludge before sludge bed dewatering.

GARLAND-DUCK CREEK PLANT (3D-23)

The Duck Creek Treatment Plant is jointly owned by the Cities of Garland and Richardson. It is a trickling filter type plant with a rated capacity of 10 mgd. Raw sewage enters this plant by gravity where it is lifted into primary clarification units and passed through the two-stage high-rate trickling filter process before being discharged without chlorination into the East Fork of the Trinity River. Sludge is digested anaerobically, and dried on sludge drying beds.

PLANO PLANT (3E-26)

The Plano Treatment Plant is a trickling filter type plant with a rated capacity of 1.85 mgd. In addition to the City of Plano this plant also serves the City of Allen and two mobile home parks. Raw sewage enters the plant by gravity and receives screening, primary clarification, single-stage trickling filtration, final clarification and chlorination before discharge into Rowlett Creek hence to Lake Ray Hubbard. Sludge is digested anerobically and dewatered on sludge drying beds.

GARLAND-ROWLETT CREEK PLANT (3E-40)

The Rowlett Creek Treatment Plant is a trickling filter type plant with a rated capacity of 2.0 mgd. It serves the part of Garland within the Rowlett Creek Drainage area and Spring Creek area and also a portion of the City of Rowlett. Current plans are to expand this plant to 6.0 mgd. Sewage enters this plant by gravity where it is screened and grit is removed. From the grit chamber flow passes into primary clarifiers, first stage trickling filters, intermediate clarifier, second stage trickling filters and final clarifier before being discharged without chlorination into Rowlett Creek and thence into Lake Ray Hubbard. Sludge is digested anaerobically and dried on sludge drying beds.

McKINNEY-NORTH PLANT (3H-3)

The McKinney North Treatment Plant serves only the McKinney Job Corp Training Center. The plant is a trickling filter type plant with a rated capacity of 0.5 mgd. Flow enters this plant by gravity where it is settled, filtered on a single stage trickling filter and receives final sedimentation before final chlorination and discharge into the East Fork of the Trinity River. Sludge is digested anaerobically and dewatered on sludge drying beds.

McKINNEY-SOUTH PLANT (3H-24)

The McKinney-South Treatment Plant serves the City of McKinney and is considered to be overloaded. It consists of a primary treatment plant followed by an oxidation pond with a rated capacity of 0.5 mgd. Sludge is digested anaerobically and dewatered on sludge drying beds. The effluent is discharged into Wilson Creek without chlorination, from which it passes into Lavon Reservoir.

LEWISVILLE PLANT (4A-81)

The Lewisville Treatment Plant is a trickling filter type plant with an existing rated capacity of 0.6 mgd. Additions to this plant are currently under construction which will bring its capacity to 1.76 mgd. When expansion is complete, sewage will enter the plant by gravity where it will be comminuted. The flow will then be pumped into clarigester units, followed by single-stage trickling filters and a final clarifier which will be utilized as a chlorine contact chamber. Effluent will be discharged to oxidation ponds and thence to Prairie Creek and the Elm Fork of the Trinity River. Sludge is digested in the clarigester units and dewatered on sludge drying beds.

A master plan on sewerage facilities for the City of Lewisville has recently been completed by Henningson, Durham and Richardson, Consulting Engineers. This master plan envisions further enlargement of the Prairie Creek plant and the construction of a regional plant on Timber Creek near the Dallas-Denton County line which would serve the Timber Creek area of Lewisville, as well as the Cities of Flower Mound and Highland Village. The Prairie Creek Plant is expected to be expanded to between 2.8 and 4.0 mgd by 1975.

TRA CENTRAL PLANT (4A-166)

The TRA Central Sewage Plant is a regional facility serving the Cities of Irving, Coppell, Addison, Farmers Branch, Carrollton, Grand Prairie and Dallas. The plant is a trickling filter type plant with a rated capacity of 30 mgd. Sewage flow enters this plant by gravity where it is screened and grit is removed. The sewage is then lifted into primary clarifiers, two-stage trickling filters chlorinated and discharged to oxidation ponds before discharge to the West Fork of the Trinity River. Sludge is thickened and digested anaerobically before dewatering on sludge drying beds.

GRAPEVINE PLANT (4B-156)

The Grapevine Treatment Plant has a rated capacity of 0.24 mgd and is a trickling filter type plant. It serves most of the City including that portion to the north and an expansion of this plant is currently being planned. Effluent is discharged into Morehead Branch thence into Grapevine Reservoir.

A new treatment plant is now being constructed in the portion of Grapevine lying in the Big Bear Creek Watershed (5A-24). This plant would have a capacity of 0.20 mgd and is not considered to be a major plant.

GAINESVILLE PLANT (4C-55)

The Gainesville Treatment Plant consists of a primary treatment plant followed by oxidation ponds and has a capacity of 1.5 mgd. Effluent is discharged directly to the Elm Fork of the Trinity River.

DENTON PLANT (4C-71)

At the present time Denton is served by an activated sludge plant and an old Imhoff plant. The present rated capacity of the activated sludge plant is 2.0 mgd, whereas the 1968 average flow was 2.6 mgd. This plant is now being expanded to a capacity of 6.0 mgd. The Imhoff plant is expected to be phased out in 1971 when the new plant expansion is complete. The expanded plant employs single-stage aeration, and final chlorinated effluent is discharged into Pecan Creek thence to Garza-Little Elm Reservoir. Sludge is digested anaerobically and will be conditioned for dewatering on drying beds by the wet air oxidation (Zimpro) process.

ARLINGTON PLANT (5E-195)

The Arlington Treatment Plant employs the trickling filter process for providing secondary treatment. Settled sludge is vacuum filtered and buried. Its rated capacity is 2.9 mgd while the average 1968 flow coming into this plant was 5.4 mgd. Thus this plant is considerably overloaded, and untreated sewage is bypassed to Johnson Creek and thence to the Trinity River. Plans have been completed for a plant expansion to 6.5 mgd. The expanded plant will use high-rate trickling filters and will also have a large aerated holding pond to retain flows in excess of plant capacity.

EULESS PLANTS

The City of Euless is served by two treatment plants; the West and the East Plants. Both plants are located along the West Fork of the Trinity River. Together these plants have a capacity of about 1.0 mgd. The City of Euless plans to discontinue operation of both treatment plants in the future when connections can be made to the TRA West Fork Interceptor System.

Euless-West Plant (5F-184). The Euless West Treatment Plant is a primary treatment type plant followed by stabilization for secondary treatment, with a rated capacity of 0.5 mgd. This plant is reported to be badly overloaded.

Euless-East Plant (5F-188). The Euless-East Treatment Plant is similar to the Euless-West Treatment Plant and also has a capacity of 0.5 mgd. This plant like the West Plant utilized anaerobic digestion of sludge and dewatering on sludge drying beds.

FORT WORTH PLANTS

The City of Fort Worth is now served by two major wastewater treatment plants; the Riverside Plant and the Village Creek Plant. These plants also serve all or part of 17 suburban communities in the metropolitan area. Both of these plants receive sewage from the same trunk sewer system and are located to the east of the City with the Village Creek Plant 10 miles downstream from the Riverside Plant. The combined capacity of the two plants is presently rated at 60 mgd, and average daily flow is now about 53 mgd. Effluent chlorination is not practiced at either plant, but the TWQB has ordered that chlorination be provided at the Riverside Plant by July 1970.

Village Creek Plant (5G-180). The Village Creek Plant is the newer of the two Fort Worth plants and is located further away from residential areas than the Riverside Plant. It uses the activated sludge process, and its present rated capacity is 30 mgd.

Plans have been completed for expanding this plant up to a capacity of 45 mgd, and chlorination of the plant effluent is planned in compliance with TWQB requirements. Further expansion of the plant is being planned.

Sewage flows reach the plant by gravity where they are measured and screened. Following screening the flow is subjected to grit removal, sedimentation, aeration, and final sedimentation. Sludge is thickened and digested anaerobically, and the digested sludge is pumped to lagoons. A 200 acre area containing drying beds is presently being completed. The treated effluent is discharged into the West Fork of the Trinity River.

The primary treatment units receive flow by gravity. Primary effluent is pumped to the secondary units, which are approximately 15 ft above the primary facilities. This permits a minimum of primary treatment in the event of a power failure. During storm periods, primary effluent in excess of secondary treatment capacity maybe overflowed to the river until the river level is approximately 8 feet above normal stage. Above this river level, the plant capacity is limited by secondary treatment capacity.

Riverside Plant (5M-101).The Riverside Plant is an old plant with some of the units having been built in the 1920's and with a number of additions having been made since that time. The plant has a rated capacity of 30 mgd, and plans are currently under way to phase out this plant when the planned expansion of the Village Creek Plant to a capacity of 75 mgd or more is accomplished. Considerable development has taken place and more is expected to take place in the areas around the plant. The plant has been overloaded at times, and odors and flies have caused numerous complaints. At present, flows above those it is desired to treat at the Riverside Plant are transmitted downstream to the Village Creek Plant with most of the flow going to the Village Creek Plant during dry weather periods.

The sewage enters this plant by gravity, where it is screened and grit is collected. Sewage is then pumped to primary clarifiers for sedimentation, to standard rate trickling filters for biological treatment and then to final sedimentation. Effluent is discharged to the West Fork of the Trinity River. Sludge is pumped to anaerobic digesters and the digested sludge is drawn off periodically to lagoons where it is allowed to dry. High river levels prevent the discharge of fully treated effluent to the river.

HALTOM CITY PLANT (5J-107)

The Haltom City Plant is a trickling filter type plant with a rated capacity of 1.2 mgd. Flows reaching the plant have been reduced from 1.6 mgd in 1967 to 0.5 mgd in 1969 because some flow has been diverted into the Fort Worth-Village Creek Plant. Effluent is discharged into Little Fossil Creek thence to the West Fork of the Trinity River.

WEATHERFORD PLANT (5Q-73)

The Weatherford Treatment Plant is an activated sludge type plant with a rated capacity of about 1.0 mgd. The plant consists of a comminutor, screen, primary clarifier, aeration tank, final clarifier and chlorine contact tank. The effluent is discharged into the watershed of the Clear Fork of the Trinity River.

CLEBURNE PLANT (8A-2)

The Cleburne Treatment Plant is a trickling filter type plant with a rated capacity of 2.4 mgd. The plant consists of screening, grit removal, and Imhoff tank for settling and digestion, trickling filter and oxidation ponds. Effluent from this plant is discharged into Buffalo Creek in the Brazos River Watershed.

WAXAHACHIE PLANT (10B-89)

The Waxahachie Treatment Plant is a trickling filter type plant with a rated capacity of 0.96 mgd. Sewage enters this plant by gravity where it is screened and comminuted. Sewage then passes through a primary clarifier and a single-stage trickling filter and a secondary clarifier before being chlorinated and discharged into Mustang Creek thence to Bardwell Reservoir. Sludge is digested anaerobically in a two-stage digester system and is dewatered on sludge drying beds.

ENNIS PLANT (11A-94)

The Ennis Treatment Plant is a trickling filter type plant with a rated capacity of 0.6 mgd. Sewage enters this plant by gravity where it comminuted and pumped up into the clarigester. From the clarigester flow passes to a single-stage trickling filter and then to oxidation ponds followed by chlorination before discharge into Cummins Creek thence to Chambers Creek. Sludge is digested in the clarigester and dewatered on sludge drying beds. The Texas State Department of Health has been conducting a study of the operation of this plant.

SEPTIC TANK SYSTEMS

GENERAL

Although over 80 percent of the existing population in the study area is presently served by sewers, about 90 percent of the study area is presently unserved by municipal sewerage systems, as indicated on Fig. IV-1 and IV-2. The predominance of the unsewered portion of the study area over the sewered portion is expected to continue through the year 2020. It is clear, therefore, that a comprehensive sewerage study of the NCTCOG area and contiguous areas within the Upper Trinity River Basin must take cognizance of the existence of individual sewage disposal systems, such as septic tanks and drain fields, in unsewered areas. These systems are commonly utilized in such areas to prevent diseases and nuisances arising from the inadequate disposal of sanitary sewage.

Septic tank systems have grown into widespread use since their introduction into the United States almost 100 years ago. Their use has brought the adyantages of modern plumbing to isolated rural areas, as well as the increasing problems associated with them in more densely populated areas. When site conditions are suitable, a well designed, constructed and operated septic tank and drain field is the most feasible method of sewage treatment and disposal for the individual household which cannot be connected to a municipal sewerage system. Newer methods of treatment and disposal for individual households such as chemical toilets, small package-type treatment units and incinerators have been developed but have not come into common usage.

Septic tank systems have remained basically unchanged during their 100 years of use. In essence they provide for the collection of waterborne household wastes in a buried vault where scum, grease, and settleable solids are removed from the liquid by gravity separation. The retained solids are digested by bacterial action and partially liquefied, and the effluent liquid drains into a subsurface drain field where it percolates into the soil.

Satisfactory operation of a septic tank system depends on the character and extent of the soil mantle, the depth to the groundwater table, size and slope of the lot, the rate of hydraulic loading, the strength and chemical characteristics of the waste, its location in relation to streams, wells and structures, and the extent of periodic maintenance. Frequently, one or more of these parameters for satisfactory operation of an existing system are not met, resulting in unsatisfactory operation and danger to public health and safety.

A survey has been conducted to determine the location of existing septic tank system concentrations in the study area as discussed below. In addition, generalized soil data have been obtained. Both the concentrations and soil data are presented on Fig. IV-3 appended to this volume, to provide a general basis on which the efficacy of septic tank systems in various areas may be judged.

SEPTIC TANK SURVEY

As a part of the survey, questionnaires and maps were prepared and sent to all County Judges, County Health Officers, City Managers, City Administrators, and City Secretaries in the Upper Trinity River Basin. Additional information utilized in this survey was obtained from U.S. Army Corps of Engineers, Water Supply Corporations, Water Districts, lake custodians, and field observations.

Locations of septic tank concentrations such as mobile home areas, and residential developments outside of sewered areas, especially those situated near reservoirs, were considered to be significant areas for investigation as a part of this study. Rural, and otherwise widely spaced individual septic tank systems, were disregarded in this survey. Areas in which significant numbers of septic tanks are known to be located are shown on Fig. IV-3.

The septic tank operational experience related by the local officials, indicates that at least 78 percent of all the septic tank areas are experiencing poor results, with some reporting a definite health and sanitation hazard due to the surfacing of untreated sewage. The general trend of the replies received would indicate that in most areas the soil lacks absorptive properties, and is unsuitable for a drain field. This is particularly true during wet weather periods.

Some of the counties in the study area have a very low population density, and rural communities served by septic tank systems in some cases are losing population to the urban areas. Those counties which appear to have increasing populations served by septic tank systems are discussed as follows:

Collin County. The principal areas of septic tank concentration in Collin County are located around the Lavon Reservoir. There are estimated to be about 460 septic tank installations around the lake located in 18 development areas. The lake management

is presently in the process of acquiring land in order to raise the normal water level of the lake about 20 feet. It is expected that this increase in water level will inundate about 100 septic tank systems and the residential areas they serve. This is expected to cause these developments to move to higher ground, but is not expected to materially change the number of residents relying on septic tanks for sewage disposal.

Raising of the normal lake level would appear to be a convenient time to institute a septic tank licensing and surveillance procedure in the area surrounding Lake Lavon. This same procedure could apply also to the area around Forney Reservoir (Lake Ray Hubbard) which has its upper reaches in Collin County.

No reports were available concerning percolation tests or other investigations to determine the suitability of the soil for septic tank systems. Soil data however, would indicate that the soil from the ground surface to a depth of about two feet is a heavy clay. While the soils maps are generalized and do not give definite data for a small area, the indication of a tight clay does warrant concern regarding proper operation of septic tank systems in the area and the desirability of installing new septic tank systems.

Dallas County. Complete records of septic tanks in Dallas County were not available. However the Dallas County Health Department indicated that septic tanks are not functional in land areas of concentrated usage such as mobile home parks.

The County does not have records of FHA homes that have been built with septic tank systems or on small communities surrounding the City of Dallas. Some of these communities have requested the Dallas County Health Department to inspect new septic tank systems being installed. In such cases the County does keep records, and it was from these records that concentrations of septic tanks were found to exist in the Cities of Duncanville, DeSoto, Irving, and Lancaster. Additional information obtained by contacting these communities individually is summarized below.

The City of Duncanville now requires an application and permit for all septic tanks, and percolation tests are required on all FHA homes. The City inspects the installation of all septic tanks, and its specifications and requirements are similar to those of the FHA. The septic tank systems are mainly concentrated in two areas; one of which is the Red Bird Addition and the other is the Winnona Gardens Addition, but no information is available as to the number of septic tanks.

The City of De Soto does not require permits for septic tank installations, but it is reported that the County Health Department inspects all tank and drain field installations. A percolation test is required on FHA homes only. The two principal areas of septic tank concentration are the Shamrock Park area, and the western part of De Soto.

The City of Irving requires a permit for septic tank installations, and a permit will not be granted if it is feasible for the applicant to connect to an existing sewer line. Percolation tests are not required by the City except in the case of FHA homes. There are 2,500 septic tanks in operation in the City of Irving, about 1,700 of which are located in a recently annexed portion of the Bear Creek drainage area. Plans have been completed for a trunk sewer extending through this portion of Bear Creek drainage area, which will make possible the elimination of these 1,700 septic tank systems.

The City of Lancaster requires a permit for the installation of a septic tank, and the City inspects the construction. Specifications for septic tank construction in Lancaster are the same as Dallas County specifications. The "Ten Mile Creek Sewerage System" is now being constructed in the area by the Trinity River Authority, and the City of Lancaster plans to extend lines to the residents now using septic tanks when the Ten Mile Creek system becomes operational.

Denton County. The earlier developments using septic tanks in Denton County are located in the area around Garza-Little Elm Reservoir and include some small towns and communities as indicated on Fig. IV-3, appended. Within the last few years a number of mobile home and trailer park type of developments have been installed in the suburbs or rural areas around Denton. This appears to be a trend, and should be viewed with some concern, because most of these areas are being served by septic tanks. Continued growth of this type of development is expected. Some of these developments have applied to the TWQB for a treatment plant discharge permit, but the majority apparently intend to use septic tanks for their method of treatment.

There are no reports of serious pollution due to septic tanks at this time. However, due to the fact that the Garza-Little Elm Reservoir serves as water supply for both Dallas and Denton, and also recognizing the fact that mobile home park developments are increasing in number, consideration should be given to a uniform licencing and control program for installation and maintenance. A more detailed description of possible pollution sources around Garza-Little Elm Reservoir was obtained from the project office of the Corps of Engineers, and this information is listed as follows:

1. Highland Village on the southwest shore of the lake is served by septic tanks. Apparent overloading causes sewage to rise to the ground surface in the drain field areas and flow into the lake. Highland Village has submitted an application for construction and operation of a prefabricated sewage treatment plant which would discharge its effluent into the lake.

2. A 50-lot subdivision on the east side of the lake has received approval from the Texas Water Quality Board to install a secondary sewage treatment plant and discharge effluent into the lake.

3. Sewage from mobile homes in the Whipporwill Trailer Park is treated in a one-half acre oxidation pond. Overflow from the pond discharges into Garza-Little Elm Reservoir, and overflows occur primarily during periods of wet weather. There is a slight odor from the pond, and some odor complaints have been received from local people. It is reported that the TWQB has instructed the operators of the park to build a larger oxidation pond and to chlorinate the effluent.

Henderson and Kaufman Counties. The principal concentration of septic tanks in these two counties is around Cedar Creek Lake. This lake is owned and controlled by the Tarrant County Water Control and Improvement District No. 1 and will supply water to Fort Worth and Tarrant County. Other data concerning septic tank installation and operation around the lake was obtained from Water District personnel and is discussed below.

The Water District owns the land around the periphery of the lake to the contour line three feet above normal lake operating level. No construction is permitted in this zone. Beyond this zone, the land is privately owned, and there is considerable

development for both recreational and permanent dwelling around the lake. At the present time, most of the sewage is handled by means of septic tank systems.

There is no ordinance or control for septic tank construction and operation on privately owned land. However, as of August 1969, no serious health hazards were known. The Water District maintains an office in the area with a full time sanitarian who frequently checks on health and sanitary conditions around the lake. Individuals reportedly contact the Water District office regarding septic tank construction and are furnished copies of the State Health Department Standards for septic tank construction and operation. Counsel on local soil conditions is also offered by the District.

The soil on the east side of the lake is generally sandy, and absorptive, and suitable for drain fields, while the soil on the west side of the lake is predominantly clay. Problems of lake pollution from septic tank systems reportedly have been very few. However, District officials indicate there have been a few cases where effluent from drain fields has been observed to rise to the ground surface and flow toward the lake. The District's procedure in such cases has been to contact the property owner for immediate corrective action. It is reported that the property owners have been very cooperative and have taken the necessary corrective steps to avoid further pollution. A minimum distance of 75 feet from the normal water surface shoreline to the nearest point in a septic tank drain field is required by the Water District.

While pollution problems from septic tank systems in the area have been minimal, we would anticipate that, as the area continues to develop and more septic tank systems are installed, the possibility of pollution from this source will increase. This is expected not only because of increasing development but because of the temporary nature and the relatively short life of most septic tank systems. The absorptive capacity of most drain fields tends to reduce with age until the fields finally fail due to "plugging up" of the soil interstices.

Parker County. The principal area of septic tanks in Parker County is along the shores of Lake Weatherford which is a source of water supply for the City of Weatherford. The lake shore lots are generally limited in size and there is little space for properly sized drain fields. No serious problems have been reported possibly because these tanks are located in an area of weekend cottages and generally are not occupied on a continuous or permanent basis. The City of Weatherford has some septic tank systems which reportedly give trouble. However, the city has a sewerage system, and septic tanks may be eliminated in the future. Other septic tank areas in the County are scattered.

Rockwall County. Septic tank concentrations in Rockwall County are located mainly in the area around Forney Reservoir (Lake Ray Hubbard), as shown on Fig. IV-3, appended. Forney Reservoir occupies a large part of Rockwall County and also is located in portions of Collin, Dallas and Kaufman Counties. Population is expected to increase considerably around this reservoir.

The City of Dallas Water Department operates Lake Ray Hubbard and is concerned particularly with possible pollution from anticipated growth on the east side of the lake because of subsurface rock conditions. No serious pollution problem has yet been reported.

Septic tank systems and/or prefabricated sewage treatment plants are considered temporary with ultimate development of intercepting sewers and treatment facilities preferred for all developing areas along the lake. Such an ultimate solution requires cooperation between the City of Dallas and developers along the lake, and the formation of an advisory council to control developers has been recommended to the City. Inasmuch as the City now has no control of potential pollution of the reservoir resulting from improperly operating septic tank or other systems, the need for permit and regulatory authority is evident.

The NCTCOG was delegated authority by the TWQB over septic tank systems around Lake Ray Hubbard at a public hearing held on June 5, 1970.

Tarrant County. The Department of Public Health for Tarrant County provided a large amount of information on septic tanks in the study area and assisted in the development of this information. The community of Crowley in the south central part of the county is partially served by septic tank systems. There are scattered areas of septic tank concentrations as indicated on the map in the southeast quadrant of the County. These areas are primarily along the highway between Mansfield and Kennedale, south of Arlington, and in the Rush Creek drainage area between Lake Arlington and the City of Arlington.

Some apartment units and some mobile home parks are served by septic tanks in the southeast quadrant of the County. The County Department of Public Health has been unable to regulate some rural developers in this area. As a result, septic tanks and drainfields have been installed in some areas where the soil is not suitable. Also, the County Department of Public Health has not been able to obtain the cooperation of some developers in constructing septic tanks and drain fields in accordance with standards established by the TSDH. As a result, some of the drain fields are a source of pollution with sewage rising to the ground surface.

The northeast quadrant of the County contains a number of areas served by septic tanks. Some of these areas are mobile home parks, and it is anticipated that the working force required by the new airport construction will stimulate development of additional mobile home parks which will, in turn, necessitate more septic tank installations. Some septic tank areas exist around Eagle Mountain and Lake Worth as indicated on Fig. IV-3 appended.

It has been estimated that roughly 33,000 persons in Tarrant County are using septic tanks as a method of sewage disposal. Personnel in the County Department of Public Health have been attempting to educate developers and property owners in acceptable septic tank and drain field construction practice. The authority to enforce construction in accordance with State Health Department Standards appears to be limited, and a large part of such construction is substandard. A licensing and surveillance program appears to be needed in some areas of the County.

Wise County. Septic tank areas are indicated on Fig. IV-3,appended. Wise County at this time is rather sparsely populated, and for the most part, the rural nature of the septic tank areas and the fact that they are mostly remote from major streams, would tend to make them of less concern than other more densely populated areas. Questionnaire data indicate that some of the septic tanks do not function properly. The area of greatest concern should probably be around Lake Bridgeport. This is a water supply reservoir, and there has been some indication of acceleration in residential development around some parts of the lake. Control of septic tank construction and operation around the lake is needed. This reservoir is owned and

operated by the Tarrant County Water Control and Improvement District No. 1, and the Water District does exercise some control over sanitary conditions around the lake. There are no written regulations and criteria in effect regarding septic tanks. The Water District uses the data as published by the TSDH as a guide.

Other Counties. As shown on Fig. IV-3, appended, there are a number of scattered septic tank concentrations, none near a major lake or reservoir, in the portions of Johnson, Clay, Archer, Young, Montague, Grayson, Fannin, Hunt, and Van Zandt counties within the study area. In Ellis County, the septic tank concentration closest to Bardwell Reservoir is in the town of Bardwell, 3 miles from the reservoir, with a 1967 estimated population of 220. In Jack County, the community of Wizard Wells, with a 1967 estimated population of 69 is situated near an arm of Lake Bridgeport.

The septic tank concentrations discussed above are located in generally rural areas which are tending to lose population. Any water quality effects from improperly operating septic tank systems in such areas are likely to be slight. Nevertheless, because many water supplies are fed by streams draining these areas, proper operation of septic tank installations is essential.

PERFORMANCE OF SEPTIC TANK SYSTEMS

79 replies were received from officials who were sent questionnaires as part of the septic tank survey. Some of the replies contained comments concerning operation of the septic tanks in their area, and the replies are summarized as follows:

Those who made no reply as to experience with septic tank operation	24
Those reporting satisfactory experience with septic tanks in their area	12
Those reporting unsatisfactory results from septic tank operation in their area	43

The above tabulation indicates that 78 percent of those reporting had unsatisfactory experience with septic tanks, and there were several in this group who reported health hazard conditions due to malfunction of septic tanks. Twenty-two percent of those relating their experience reported satisfactory operation of septic tanks in their area. It was also noted that some of the replies indicated that poor results were due to improper installation. The results of the survey would indicate that septic tanks in concentrated areas should be discouraged in general and prohibited where there is any other treatment method available.

SOIL CONDITIONS

General. Soils within the study area vary from the sandy soils of the West Cross Timbers and East Cross Timbers to the black waxy soils of the Grand Prairie and Blackland Prairie regions of Texas. Also, a considerable area of shallow rock soil exists along the ridge between Fort Worth and Weatherford and along the Austin escarpment extending in a northeast-southwest direction through parts of Ellis and Dallas Counties. Alluvial soils occur in creek and river valleys, becoming more extensive in the southeastern portion of the study area.

A large percentage of the soils, particularly in the eastern half of the study area, are clay. This type soil is generally characterized by low permeability and slow percolation rates and is generally undesirable for septic tank drain fields. When other factors are

satisfactory, relatively slow percolation rates can sometimes be compensated for by increased area of drain field.

Soil Maps. Generalized soil maps for each county in the study area and significant fringe areas were obtained from the Department of Soil and Crop Sciences, Texas A&M University. These maps were compiled by the Soil Conservation Service (SCS) of the U.S. Department of Agriculture and show the dominant soil series and their approximate extent as well as descriptions of the various soil types. Soil Series information from these maps has been assembled and is shown in Fig. IV-3 appended. Descriptive information is given in Appendix E.

These SCS maps, while considered the best available source of information covering the entire study area, are useful mainly as a general indication of likely suitability or unsuitability for a particular area. While dominant soil series are shown and described on the maps, smaller areas of other soils occur within the delineations shown. Since these soil maps were prepared primarily for agricultural use by persons in the field of agricultural soils technology, some engineering properties, important for this study, such as percolation rates at depths of 24 inches and below, and total depth to impermeable stratum or bedrock, are not given.

For any particular location, more specific subsurface information is required on which to base decisions on suitability for septic tank and drain field installation.

GOVERNMENT REGULATIONS

Regulations and recommendations concerning septic tank practice have been set forth by the U.S. Public Health Service, Texas State Department of Health and Texas Water Quality Board. Local regulations are often nonexistent, as discussed above. Among the places where they are in effect, they lack uniformity. Requirements have also been established by the Federal Housing Authority and the Uniform Plumbing Code. Some comparative septic tank system and setback requirements are shown in Tables IV-2 and IV-3.

The U.S. Public Health Service (USPHS) has been responsible for much of the literature published on the subject of septic tanks. It has conducted and sponsored research in this field. Its publication, "Manual of Septic Tank Practice" has become the basic reference for septic tank and drain field design. USPHS requirements for septic tank systems are shown in Table IV-2 in comparison with requirements of other organizations.

The Texas State Department of Health (TSDH) exercises general supervision and control of all phases of public health work in the State through development of standards and issuance of regulations, etc., as discussed in Chapter XII. Under the State of Texas Sanitation and Health Protection Law (Article 4477-1 Vernon's Civil Statutes and Amendments), minimum standards of sanitation and health protection measures were established. The TSDH is authorized to carry out the provisions of this Article, and penalties are provided for violation of these minimum standards.

The TSDH is empowered to take all necessary procedures essential to the protection of any water body in Texas from pollution by sewage, and it is represented on the Texas Water Quality Board. Under this authority the maintenance of an overflowing septic tank is [illegible]d to be a nuisance dangerous to the public health. In addition, the TSDH [illegible]es that all effluent from new septic tanks must be disposed of through properly designed subsurface drainage fields in order to prevent the pollution of

TABLE IV-2. COMPARATIVE SEPTIC TANK SYSTEM REQUIREMENTS

	REQUIREMENTS			
	FHA(1)	USPHS(2)	UPC(3)	TSDH(4)
Minimum Septic Tank Sizes (gals)				
1-2 Bedrooms	750	750	750	750
3 Bedrooms	900	900	1,000	1,000
4 Bedrooms	1,000	1,000	1,200	1,000
5 Bedrooms	1,250	1,250	1,500	-
Gallons per additional bedroom	250	250	150	250
Drain Fields				
Percolation test required	Yes	Yes	No	Yes
Surface used for design	Bottom	Bottom	Bottom	Bottom
Trench width required (in.)	12-36	12-36	18-36	18-36
Minimum gravel depth below tile (in.)	6	6	12	6
Area of Trench Bottom Per Bedroom (Minimum)(sq ft)				
15 Minutes per in percolation rate	71(5)	71	30	190
30 Minutes per in percolation rate	94	94	45	250
60 Minutes per in percolation rate	124	124	(6)	330
Minimum Trench Spacing (ft)	6	6	6	6.5

Notes:

(1) Federal Housing Authority
(2) United States Public Health Service
(3) Uniform Plumbing Code
(4) Texas State Department of Health
(5) Assumes 2-ft trench depth and 18-in trench width
(6) As required by Health Department

TABLE IV-3. COMPARATIVE SETBACK REQUIREMENTS FOR SEPTIC TANK SYSTEMS

LOCATION	Requirements (ft)		
	FHA(1)	UPC(2)	TSDH(3)
Septic Tank To			
Buildings	5	5	5
Property Lines	10	5	10
Wells	50	50	50
Streams and Lakes	--	50	75
Water Lines	10	5	--
Drain Fields To			
Buildings	5	8	15
Property Lines	5	5	10
Wells	100	50	150
Streams and Lakes	--	50	75
Water Lines	10	5	--

(1) Federal Housing Authority
(2) Uniform Plumbing Code
(3) Texas State Department of Health

drinking water supplies and nuisances from developing. Home Rule cities are not prevented from enacting more stringent septic tank ordinances than the minimum requirements of the TSDH.

The TSDH has published a pamphlet entitled "A Guide to the Disposal of Household Sewage," which presents recommended practices covering septic tank and drain field construction in areas where municipal sewerage is not available. This pamphlet has been used as the basis for local ordinances regulating septic tank system installation and is referred to extensively hereinafter.

The Texas Water Quality Board has broad powers in maintaining the quality of the waters of the State under the Texas Water Quality Act (as amended by Senate Bill 147). Section 3.22 of SB 147 states:

> "(a) Whenever it appears that, because of the nature of the soil or drainage in an area, the use of septic tanks in the area should be controlled or prohibited to prevent pollution, the Board may hold a public hearing in or near the area to determine whether an order should be entered controlling or prohibiting the installation or use of septic tanks in the area. Before entering such an order, the Board shall consult with the State Commissioner of Health for recommendations concerning the impact of the use of septic tanks in the area on public health. If the Board finds after the hearing and after consulting with the State Commissioner of Health that an order controlling or prohibiting the use of septic tanks in the area is necessary to prevent pollution that may directly or indirectly injure the public health, the Board may enter an order to do one or more of the following:
>
> (1) Limit the number and kind of septic tanks which may be used in the area;
>
> (2) Prohibit the installation and use of additional septic tanks in the area; or
>
> (3) Provide for a gradual and systematic reduction of the number or kind of septic tanks in the area.
>
> The Board may also provide in the order for a system of licensing the installation of additional septic tanks in the area, in which case no person may install a septic tank in the area without a license.
>
> (b) Whenever it appears to the Commissioner's court of any county that, because of the nature of the soil or drainage in an area in the county, the use of septic tanks in that area should be controlled or prohibited to prevent pollution that may directly or indirectly injure the public health, the county may proceed in the same manner and in accordance with the same procedures as the Board to hold a hearing and enter an order, resolution, or other regulation controlling or prohibiting the installation or use of septic tanks in that area. The order, resolution or regulation may provide the same restrictions and requirements as is authorized for an order of the Board entered under

Subsection (a) of this section. Before the order, resolution, or other regulation becomes effective, the county shall submit it to the Board and obtain the Board's written approval."

RECOMMENDED SEPTIC TANK POLICY

The development of a recommended septic tank policy for the NCTCOG area has been based on the same general criteria used to evaluate municipal sewerage systems. Through the utilization of such a common basis of comparison, the achievement of water quality objectives may be approached in an equitable manner throughout the study area.

There are two sources of design and operational procedure for septic tank systems considered to be satisfactory for application in the NCTCOG area. One of these is a publication the TSDH, entitled "A Guide to the Disposal of Household Sewage." The other source is an article by Cotteral and Norris in the Journal of the Sanitary Engineering Division, ASCE, August 1969 issue.

The general criteria used are those listed by Cotteral and Norris for use in Marin County, California as follows:

1. The septic tank system must meet all health and safety requirements.
2. It must satisfy the aesthetic requirements of the area.
3. It must be acceptable to the residents.
4. It must be practicable and workable and must provide a degree of reliability comparable to that of a well planned and maintained community sewerage system.
5. It must be economically feasible and should be the most economical alternative.
6. Controls necessary to achieve the objective listed above must be easily enforceable and legally sound.

There can be no guarantee of acceptable performance for any septic tank system. A reasonable useful life for such a system may only be achieved through the application of strict design criteria, the utilization of the best construction practices, and the establishment of an effective continuous program of surveillance and maintenance. However, consideration should be given in advance to ultimate failure and the provision of corrective measures.

In developing areas, septic tanks may be suitable, in some cases, on an interim basis with provision for future connection to municipal sewerage systems. In other areas, where it is considered desirable to limit or prevent residential or commercial development, the unsuitability of sites for septic tank systems, and remoteness from municipal sewerage systems may be of positive value to responsible planning agencies.

Site Suitability. Before any septic tank system is installed, the site must be found suitable. The site must be suitable from the standpoints of soil characteristics, lot size and topography. Acceptable soil within the drain field area should be a minimum of 5 ft in depth and the level of the seasonal high groundwater table should be at least 3 ft below the bottom of the proposed drain field trench. A site subject to flooding is not

suitable. Topography should permit gravity flow through the entire process. Soil borings should establish the depth, extent and character of the soil mantle, and the location of bedrock or other impervious strata. In general such an investigation should reasonably define the site characteristics within the upper 8 ft.

Investigations should be conducted to confirm that the soil possesses sufficient percolative capacity to support the leaching process. This might be achieved by observation in conjunction with experience within the area, but where tight soils are encountered, as in most of the area, percolation tests should be required.

Lot size requirements for septic tank systems depend greatly upon soil characteristics as discussed above, but a minimum lot size of one acre should generally be adequate with proper soil conditions provided that slopes are not too steep. The lot size requirement should provide for standard setbacks and desirable location of the residence.

The site should permit the location of the septic tank system components a safe distance from any water supply sources so as to prevent a health hazard.

Protection of Water Supply. While public ownership of all watershed lands is undoubtedly the most satisfactory means of safeguarding the quality of a public water supply, such a course is not always possible. Several major water supply reservoirs in the study area are presently faced with the threat of pollution by residential development of watershed lands not owned by the water supply agency. Where septic tank systems are proposed for these lands, the potential hazard to a public water supply justifies the adoption of more stringent requirements.

Of particular importance is the assurance that septic tank effluent will travel a sufficient distance through the soil mantle to eliminate any significant danger of bacterial contamination of the reservoir. About 150 feet is recommended as the minimum setback distance from any point in the septic tank system to the nearest cut, embankment, permanent, or intermittent stream or other point where the effluent might surface.

Special care should be taken to insure that the minimum depth of soil to bedrock or other impervious strata is available. Where the bedrock is loosely bedded or heavily fractured, presenting the possibility for channeling of the effluent, consideration should be given to a further increase in setback distances. Combined with a regular program of drain field inspection, supplemented as necessary by bacteriological testing of the adjacent reservoir and tributary streams, these requirements should eliminate serious risk of reservoir contamination until such time as municipal sewerage service can be provided.

Design and Construction Considerations. The principal elements of a septic tank system are the house sewer, the septic tank, and the soil absorption system or drain field and should, in general, follow the recommendations of the Texas State Health Department. Recommendations as to the design and construction of these elements are presented below.

House Sewer. The line from the house plumbing system to the septic tank should be constructed of structurally sound pipe such as cast iron, vitrified clay, or concrete. A minimum diameter of 4-in pipe (5 or 6-in is preferable) should be used and the pipe

laid on a straight grade not flatter than 1/4-in per ft. Jointing material should prevent leakage and entry of roots.

Septic Tank. The tank must be watertight, structurally sound, and durable. The most commonly used material is precast reinforced concrete which is quite satisfactory as well as economical. Functionally, the tank must be large enough to provide detention time for most of the solids to settle to the bottom and for floating scum to rise to the top with sufficient clear space between the sludge in the bottom and the scum on top for clarification of the sewage to take place. Inlet and outlet devices must be arranged to prevent either the sludge or floating scum from being carried out with the effluent.

The minimum size of septic tanks is usually based on the number of bedrooms served. Minimum sizes shown in Table IV-2 are seen to be very similar for the different regulatory bodies listed. These minimum sizes include provisions for garbage disposal units and automatic washers which are in such common use that space should always be provided for the extra solids and liquids that these appliances generate.

All designs of septic tanks assume that sludge deposits and scum will not be allowed to build up to the point that incoming sewage will displace these solids and force them out with the effluent. Yearly inspection and pumping out of the tank, when the sludge level reaches within 12-in of the outlet, should be required.

Two-compartment tanks or two tanks in series are more efficient in removing solids, add to the life of the drain field,and consideration should be given to this requirement for all new systems.

Drain Field. The function of the drain field is to provide a means whereby the liquid effluent from the septic tank will seep into the ground at a slow rate without creating a health hazard or nuisance.

Lengths of drain fields required are based on percolative capacity of the soil as evidenced by percolation tests with a substantial factor of safety. Design should be based on TSDH requirements as shown in Table IV-2. Methods of performing percolation tests are well described in "A Guide to the Disposal of Household Sewage." No vehicular traffic should be permitted in the drain field at any time after its construction unless the field is adequately protected.

Maintenance and Expected Life Span. Required inspection by qualified personnel during construction should insure the use of proper materials and that good construction practices are followed. If this is done, maintenance or repairs will be infrequent except for periodically pumping out the tank to prevent excessive sludge buildup and drain field clogging.

Eventually, even the best designed and operated systems will fail *due to the plugging up of the soil interstices.If sludge and scum* are allowed to pass from the tank in the effluent, this process will be accelerated and the life of the system reduced. Enforced inspection and proper maintenance will delay ultimate failure and extend the life of septic tank systems to the maximum.

The limited life span of septic tank systems is a serious limitation on the desirability of their use. The expected life span of septic tank systems is generally considered by

authorities to be of the order of ten years. In the event of failure, replacement of the drain field may be possible, but this remedy cannot always be depended on in built-up areas because of limited available space.

Because of the limited useful life of septic tank systems generally, this method of sewage disposal should be considered temporary. These systems should be replaced by municipal collection and treatment systems at the earliest practicable date, especially in areas of population concentration.

Multifamily, Commercial, and Institutional Facilities. While the recommendations presented herein are concerned primarily with the problems of individual household sewage disposal system, the same general principles apply with equal validity to larger installations. Thus, the same recommendations made for home septic tank systems are equally applicable to systems which service multifamily, commercial, and institutional facilities. Since there is no way to establish standard loading conditions for installations of this type, each septic tank system must be designed specifically for the anticipated conditions of service. This requires that percolation tests and the design of the septic tank and drain field system should be done by a registered professional engineer who is qualified in the sanitary field.

Implementation of Controls. The Texas Water Quality Board has the necessary explicit authority to set up and enforce such control measures on septic tank systems and may designate a local authority as its agent in inspecting and assuring compliance with its orders. In practice, this is done through an order of the Board after evidence presented at a public hearing has established the need for such action. In June 1970 the Board designated the NCTCOG as its agent around Lake Ray Hubbard. The Board has designated the Trinity River Authority as its agent for the purpose of inspecting septic tank systems in another part of the Trinity River Basin, specifically in the Lake Livingston Water Quality Zone (Order No. 69-5). The TRA is authorized to present to the Board its recommendations for or against the granting of licenses in that area. Septic tanks in that area may not be constructed or operated without a valid license.

A number of cities in the study area now have septic tank ordinaces of varying effectiveness and many others exercise limited control.

Septic tank problem areas are considered in two categories which appear to require somewhat different control procedure, as listed below.

1. Areas around lakes where direct pollution of water supplies is a matter of serious public health concern.

2. Housing developments within the Dallas-Fort Worth metropolitan area and small communities located throughout the remainder of the study area, where sewage flows may exceed the absorptive capacity of drain fields.

Regulation of the construction, operation, and maintenance of septic tank systems requires that a governmental agency (or agencies) have the legal authority and the staff to accomplish such regulation. The TWQB should delegate its regulatory authority over septic tank systems in the North Central Texas region to a regional agency in the area. The use of the term "regional agency" is intended to represent whatever organizational structure that may evolve from the adoption of this report as the official area-wide plan for water pollution abatement as discussed in Chapter XII. Under such

an arrangement the regional agency would have authority similar to but broader than that delegated to the NCTCOG in the Lake Ray Hubbard area and to the TRA in the Lake Livingston Water Quality Zone.

In the case of the areas around water supply reservoirs (Category 1), local agencies such as the Tarrant County Water Control and Improvement District No. 1 and the North Texas Municipal Water District should enforce septic tank regulations in areas under their jurisdiction. The Tarrant County Water Control and Improvement District No. 1 presently owns and operates all of Fort Worth's water supply reservoirs except Lake Worth. Such districts should carry out their activities in coordination with the regional agency. The City of Fort Worth owns Lake Worth.

The City of Dallas owns the Lake Ray Hubbard water supply reservoir and others. The City of Dallas owns some storage capacity in Grapevine and Garza Little Elm Reservoirs, but these reservoirs were built by the Corps of Engineers and are owned by them. The cities, water districts, and Corps of Engineers should enforce septic tank regulations in the area around their reservoirs in coordination with the regional agency.

For all remaining areas of the North Central Texas region (including areas in Category 2), the County Health Department of each county should enforce septic tank regulations in coordination with the regional agency. In the event that an effective County Health Department does not exist, septic tank regulations should be administered directly by the regional agency.

The above organization of responsibility may be expected to greatly aid the enforcement of septic tank regulations within the study area. In addition, the coordination of all regulatory activities by the regional agency will assure greater uniformity in enforcement. The TWQB is presently considering the development of a uniform code recognized by all.

The authority to inspect septic tank systems under the jurisdiction of the regulating agency should be provided. Right of reasonable access to private property for such purposes should be guaranteed. Inspections should determine the signs of current or recent failure of the drain field. Where evidence of possible failure appears, additional inspections scheduled for periods of adverse conditions should be arranged.

Two major requirements must be satisfied by any program which is established to control septic tank installation and operation. First, procedures must be established to require individual homeowners to participate in the surveillance and inspection program and to obtain compliance with required preventive and corrective maintenance; and second, the cost of the program must be borne by the septic tank owners included in the program.

One method which will satisfy these requirements is the mandatory issuance of annually renewable septic tank licenses for all residences served by septic tank systems within the study area. The issuance of these licenses would be dependent upon satisfactory compliance with the requirements of the inspection program, and license fees would cover the cost of the program.

The regional agency in coordination with designated cities, counties, and districts should be responsible for the following:

1. Defining, distributing, and upgrading septic tank general design criteria and operating procedures in conformance to TWQB requirements, including the definition of areas where septic tank installations are prohibited.

2. Processing applications for new septic tank systems and repairs on existing systems.

3. Interpreting submitted data and supplemental information and defining specific design criteria for each particular installation.

4. Reviewing and approving system design.

5. Issuing construction or repair permits for all septic tank work and collecting permit fees.

6. Inspecting and approving all new construction and repairs.

7. Issuing annual septic tank licenses for all residences served by septic tanks within its jurisdiction.

8. Notifying homeowners of repairs, replacement, or maintenance which must be accomplished within a given period.

9. Confirming homeowners' compliance with maintenance and corrective procedures, and renewing septic tank licenses.

10. Initiating legal action against violators of mandatory procedures.

With the preceding responsibilities vested in the regional agency, the applicant then becomes responsible for the following:

1. Securing the services of a qualified engineer to perform the required soils investigation and percolation tests.

2. Preparing and submitting the application for construction of a new septic tank system.

3. Design of the septic tank system in conformance with standard or modified design criteria provided by the regulating agency.

4. Constructing the system.

5. Pumping of the septic tank by a licensed septic tank pumper, as the need arises or when required by the regulating agency.

6. Repairing damage to the septic tank system.

It is recommended that minimum standards to be enforced by a regional agency be in accordance with instructions in " A Guide to the Disposal of Household Sewage," published by the Texas State Department of Health, or the latest official revisions thereof. Covered in these instructions are site considerations, soil testing including

percolation tests, design and construction of components of these septic tank systems, inspection, and maintenance.

The successful control and administration of the regional licensing and surveillance program herein recommended is totally dependent on the agency charged with its accomplishment. This agency must be given sufficient staff, funds, and authority to attack the problem with flexibility under a rational and uniform approach. Such powers and responsibilities, in our opinion, should be vested in a region-wide organization discussed in Chapter XII.

Implementating the above recommendation should successfully prevent serious health hazards from developing in unsewered areas and will protect home buyers from being saddled with sub-standard individual sewage disposal systems.

REFERENCES

1. Advisory Commission on Intergovernmental Relation, "Intergovernmental Responsibilities for Water Supply and Sewage Disposal in Metropolitan Areas," Oct., 1962.

2. Cotteral, J. A. Jr., and Norris, D. P., "Septic Tank Systems," Journal of the Sanitary Engineering Division, ASCE, 1969.

3. "A Guide to the Disposal of Household Sewage," Texas State Department of Health, Division of Sanitary Engineering, Austin, Texas.

4. Institute of Urban Studies, "Soil Survey: Potential for Urban Texas," University of Texas, Arlington, Texas, Nov., 1969.

5. "Manual of Septic-Tank Practice," U.S. Department of Health Education, and Welfare, Public Health Service, Washington, D.C., 1963.

6. "Rules of the Texas Water Quality Board," published by the Texas Water Quality Board, Austin, Texas.

7. Texas Sanitation and Health Protection Law of 1945, (Article 4477-1, Vernon's Annotated Civil Statutes), 1961.

8. Texas Water Quality Act of 1967, with later amendments.

9. Texas Water Quality Board, Order No. 69-5.

10. "Uniform Plumbing Code," Western Plumbing Officials, 1964.

CHAPTER V

QUANTITY AND QUALITY OF WASTEWATER

The development of criteria for use in designing sewers, pumping stations and treatment facilities requires the investigation and analysis of population, water consumption, and wastewater or sewage flow trends.

POPULATION PROJECTIONS

Projections of future population and its distribution are necessary to permit estimates of future sewage flow in each portion of the study area to be made. Distribution of present and projected population in the study area has been performed by CONSAD Research Corporation for NCTCOG utilizing available information such as Census publications, current development policies, previous planning studies and transportation studies. (1970 U.S. Census figures were not available during the preparation of this report.)

Projected total future populations of counties within the study area were based on University of Texas forecasts except as adjusted after conferences with local officials. Residential and employment populations and population densities for zones within counties in the study area were projected by CONSAD for the years 1970, 1975, 1980, 1990 and 2000. Employment population is considered to mean the number of people who are employed in manufacturing and commercial activities in an area regardless of residence, and CONSAD projections have been adjusted for use in this study.

Results of the CONSAD population distribution study have been used herein with modifications in several areas where present and anticipated growth appeared to warrant. In addition, these figures have been projected to the year 2020. Projected total residential populations for the ten-county NCTCOG area are shown in Table V-1. The total residential population of the NCTCOG area in 1967 was estimated at 2,113,940. By the year 2020 the residential population is expected to increase to about 7,619,300.

Table V-2 shows watersheds within the study area and comparisions between total residential population by watershed as projected by CONSAD and as modified for use in this study. Locations and limits of the watersheds are shown on Fig. V-1 and are referenced to Table V-2 by watershed numbers.

Not all of the population within the study area is expected to be provided with sewerage facilities during the study period. Therefore, the population served by such facilities will in general be less than the total projected populations. The projected sewered residential populations used for this study are shown in Table V-3 and referenced by node numbers assigned to existing and potential sewage treatment plants or major loading points. These node numbers contain prefixes corresponding to watershed numbers on the map presented on Fig. V-1.

Population projections developed as discussed above are based upon considerations of current and anticipated development trends. These trends could be modified in the future if development is controlled because of water supply, sewerage, drainage,

TABLE V-1. RESIDENTIAL POPULATION PROJECTIONS FOR THE NCTCOG AREA

NAME OF COUNTY	POPULATION PROJECTIONS (1)							
	1960 (2)	1967 (3)	1970	1975	1980	1990	2000	2020
COLLIN	41,250	56,820	73,770 (54,820)	109,380 (62,330)	183,590 (70,340)	334,590 (87,830)	430,000 (105,200)	492,900
DALLAS	951,530	1,201,620	1,419,860 (1,437,860)	1,675,240 (1,662,480)	1,977,020 (1,839,710)	2,534,620 (2,271,740)	2,948,200 (2,664,000)	3,571,100
DENTON	47,430	70,550	73,280 (67,800)	92,250 (78,020)	113,810 (88,280)	145,210 (108,870)	177,000 (130,000)	231,400
ELLIS	43,400	46,880	52,400 (47,910)	60,240 (52,160)	69,590 (57,730)	88,210 (72,860)	113,000 (98,000)	170,000
JOHNSON	34,720	43,910	38,240 (36,240)	40,480 (38,480)	43,700 (41,700)	53,100 (51,100)	68,900 (68,900)	91,300
KAUFMAN	29,930	33,500	33,650 (32,080)	36,660 (34,100)	40,270 (36,740)	48,520 (43,920)	57,900 (51,200)	95,100
PARKER	23,810	27,700	28,580 (28,100)	29,880 (30,770)	31,580 (33,480)	34,030 (39,030)	39,100 (44,100)	51,200
ROCKWALL	5,880	5,810	8,500 (6,310)	15,500 (10,050)	25,500 (14,440)	37,500 (25,850)	52,000 (52,000)	60,000
TARRANT	538,960	607,710	650,650 (730,000)	904,360 (900,000)	1,207,280 (1,099,950)	1,689,560 (1,630,000)	2,074,000 (1,980,000)	2,819,400
WISE	17,010	19,440	20,200 (16,740)	21,790 (16,750)	22,710 (16,860)	25,500 (17,380)	28,700 (17,800)	36,900
Total	1,733,920	2,113,940	2,399,130 (2,457,860)	2,985,780 (2,885,140)	3,715,050 (3,299,230)	4,990,840 (4,348,580)	5,988,800 (5,211,200)	7,619,300

(1) Projections from 1970 through 2000 are based on data furnished by CONSAD Research Corporation, and modified in areas where present and anticipated growth appear to warrant. CONSAD projections are shown in parentheses.

(2) 1960 U. S. Census data.

(3) Estimates taken from 1968-1969 Texas Almanac.

TABLE V-2. DISTRIBUTION OF RESIDENTIAL POPULATION DATA BY WATERSHEDS IN THE NCTCOG STUDY AREA

Watershed No.	Watershed	Area (Acres)	Projected Population 1970	1975	1980	1990	2000	2020
Trinity River Watershed								
1A.	Trinity River[1]	217,800	6,980	7,370	7,940	8,980	10,100	13,000
1B.	Smith & Walker Creeks	68,970	5,140 (4,690)	5,710 (4,840)	6,440 (5,000)	7,860 (5,500)	9,200 (6,300)	11,800
1C.	Red Oak Creek	151,230	11,730	15,470	18,910	28,030	39,500	72,200
1D.	Ten Mile Creek	68,910	37,400 (31,960)	60,920 (49,640)	88,810 (67,060)	138,530 (102,370)	194,700 (143,000)	302,600
1E.	Parson's Slough	35,170	22,540	30,170	37,650	53,150	71,800	114,600
1F.	Prairie Creek	16,470	54,970	65,040	75,860	92,080	117,400	148,700
1G.	Five Mile Creek	45,050	104,210	131,260	143,690	193,850	223,100	265,700
1H.	White Rock Creek	89,390	387,010 (369,510)	430,340 (406,330)	483,320 (441,590)	553,350 (502,170)	613,800 (543,000)	679,000
1I.	Dallas Plant Area	60,190	278,800 (265,090)	295,340 (278,390)	314,670 (294,560)	349,560 (322,860)	384,400 (349,900)	409,300
1J.	Coombs Creek	22,670	203,920	227,320	248,110	278,250	296,500	306,100
	Subtotals	775,850	1,112,700 (1,075,600)	1,268,940 (1,215,830)	1,425,400 (1,340,370)	1,703,640 (1,587,240)	1,960,500 (1,800,600)	2,323,000
Cedar Creek Watershed								
2A.	Lower Cedar Creek	309,200	19,800	21,520	23,480	29,090	35,900	49,900
2B.	Upper Cedar Creek	189,700	5,030	5,050	5,080	5,400	5,600	6,300
2C.	Kings Creek	185,820	24,640 (24,290)	26,730 (26,390)	30,150 (28,940)	36,340 (36,030)	43,600 (45,700)	77,900
	Subtotals	684,720	49,470 (49,120)	53,300 (52,960)	58,710 (57,500)	70,830 (70,520)	85,100 (87,200)	134,100
East Fork Trinity River Watershed								
3A.	Lower East Fork	54,860	10,780	15,290	18,870	29,670	40,400	64,900
3B.	East Forney Reservoir Area	102,540	8,990 (6,670)	14,760 (9,880)	23,940 (13,540)	34,910 (23,130)	46,800 (43,900)	53,700
3C.	Mesquite Creek	35,420	61,520	78,310	80,470	124,010	147,100	197,800
3D.	Duck Creek	24,860	70,700 (46,660)	85,100 (54,510)	113,800 (64,510)	188,100 (76,310)	196,000 (90,900)	201,700
3E.	Rowlett Creek	77,570	26,800 (36,830)	47,020 (42,420)	89,910 (52,430)	200,830 (61,720)	268,200 (85,700)	300,200
3F.	Spring Creek	23,410	26,500 (17,590)	41,500 (21,260)	79,700 (24,960)	156,060 (32,210)	162,800 (40,700)	162,800
3G.	Muddy Creek	68,580	7,870	12,640	23,800	34,410	46,100	68,600
3H.	Upper East Fork Trinity	195,130	27,350 (22,260)	30,370 (25,240)	34,210 (29,070)	47,210 (37,110)	71,200 (44,800)	88,700
3I.	Sister Grove Creek	100,660	5,670	5,890	6,240	7,130	7,800	9,600
3J.	Pilot Grove Creek	157,750	8,430	8,640	9,710	10,970	12,000	14,200
	Subtotals	840,780	254,610 (224,280)	339,520 (274,080)	471,650 (323,600)	833,300 (436,670)	998,400 (559,400)	1,162,200
Elm Fork Trinity Watershed								
4A.	Lower Elm Fork Trinity	117,920	152,520 (139,540)	181,390 (164,590)	229,010 (188,630)	353,100 (236,310)	432,400 (285,800)	531,000
4B.	Denton Creek	458,240	23,480 (20,230)	33,190 (30,450)	47,760 (42,680)	82,940 (76,270)	108,000 (100,000)	135,000
4C.	Upper Elm Fork Trinity	430,720	64,110	80,850	89,230	109,190	119,300	134,000
4D.	Hickory Creek	111,360	14,500	19,200	22,130	28,830	35,500	35,500
4E.	Clear Creek	240,640	4,640	4,880	5,130	5,640	7,400	8,300
4F.	Mustang & Little Elm	56,960	4,470	4,640	4,820	5,210	5,600	6,400
4G.	Isle du Bois Creek	94,720	5,100	5,460	5,870	6,830	7,100	8,000
	Subtotals	1,510,560	268,820 (252,590)	329,610 (310,070)	403,950 (358,490)	591,740 (468,280)	715,300 (560,700)	858,200

NOTE: Population data are based on estimates prepared by CONSAD. In instances where CONSAD data were modified for study purposes, the CONSAD data is shown in parentheses and the modified data shown directly above.

(1) Approximately 82,000 acres and 60% of the population of Watershed 1A are in Navarro County, which is not within the NCTCOG study area.

(2) Approximately 76,000 acres and 20% of the population of Watershed 10A are in Navarro and Hill Counties, which are not within the NCTCOG study area.

(3) Excludes population in those portions of Watersheds 1A and 10A which are outside the NCTCOG study area.

Watershed No.	Watershed
West Fork Trinity Watershed	
5A.	Big Bear Creek
5B.	Little Bear Creek
5C.	Mountain Creek
5D.	Walnut Creek
5E.	Johnson Creek
5F.	Lower West Fork
5G.	Village Creek
5H.	Rush Creek
5I.	Walker Branch
5J.	Big Fossil Creek
5K.	Little Fossil Creek
5L.	Marine Creek
5M.	Middle West Fork
5N.	Sycamore Creek
5P.	Farmers Branch
5Q.	Clear Fork Trinity
5R.	Mary's Creek
5S.	Upper West Fork
5T.	Big Sandy Creek
	Subtotals
Brazos River Watershed - Parker County	
6A.	Brazos River Portion of Parker County
	Subtotal
Brazos River Watershed - Johnson County	
7A.	Brazos River Portion of Johnson County
	Subtotal
Nolands River Watershed	
8A.	Nolands River
	Subtotal
Richland Creek Watershed	
9A.	Richland Creek Portion of Ellis County
	Subtotal
Chambers-Waxahachie Creeks Watershed	
10A.	Chambers Creek
10B.	Waxahachie Creek
	Subtotals
Cummins Creek Watershed	
11A.	Cummins Creek Portion of Ellis County
	Subtotal
Sabine River Watershed	
12A.	Sabine River Portion of Kaufman, Rockwall, and Collin Counties
	Subtotals
	Totals
Study Area Population[3]	

-2. DISTRIBUTION OF RESIDENTIAL POPULATION DATA BY WATERSHEDS IN THE NCTCOG STUDY AREA

pulation 1990	2000	2020
8,980	10,100	13,000
7,860 (5,500)	9,200 (6,300)	11,800
28,030.	39,500	72,200
138,530 (102,370)	194,700 (143,000)	302,600
53,150	71,800	114,600
92,080	117,400	148,700
193,850	223,100	265,700
553,350 (502,170)	613,800 (543,000)	679,000
349,560 (322,860)	384,400 (349,900)	409,300
278,250	296,500	306,100
,703,640 ,587,240)	1,960,500 (1,800,600)	2,323,000
29,090	35,900	49,900
5,400	5,600	6,300
36,340 (36,030)	43,600 (45,700)	77,900
70,830 (70,520)	85,100 (87,200)	134,100
29,670	40,400	64,900
34,910 (23,130)	46,800 (43,900)	53,700
124,010	147,100	197,800
188,100 (76,310)	196,000 (90,900)	201,700
200,830 (61,720)	268,200 (85,700)	300,200
156,060 (32,210)	162,800 (40,700)	162,800
34,410	46,100	68,600
47,210 (37,110)	71,200 (44,800)	88,700
7,130	7,800	9,600
10,970	12,000	14,200
833,300 (436,670)	998,400 (559,400)	1,162,200
353,100 (236,310)	432,400 (285,800)	531,000
82,940 (76,270)	108,000 (100,000)	135,000
109,190	119,300	134,000
28,830	35,500	35,500
5,640	7,400	8,300
5,210	5,600	6,400
6,830	7,100	8,000
591,740 (468,280)	715,300 (560,700)	858,200

AD data were modified for
directly above.

rro County, which is not

rro and Hill Counties,

the NCTCOG study area.

Watershed No.	Watershed	Area (Acres)	Projected Population 1970	1975	1980	1990	2000	2020
West Fork Trinity Watershed								
5A.	Big Bear Creek	51,960	36,780 (36,780)	60,000 (53,300)	82,000 (69,600)	121,000 (106,800)	160,000 (130,000)	220,000
5B.	Little Bear Creek	16,000	12,280	16,050	20,670	33,800	47,500	65,000
5C.	Mountain Creek	151,800	89,480 (87,250)	127,500 (123,470)	179,890 (150,900)	269,210 (211,230)	360,700 (260,000)	476,200 (315,000)
5D.	Walnut Creek	55,680	7,130 (6,980)	15,960 (14,990)	34,520 (24,830)	72,240 (52,860)	93,200 (69,000)	122,800 (84,000)
5E.	Johnson Creek	12,800	60,500 (39,570)	63,500 (44,960)	66,300 (51,110)	72,000 (65,030)	77,500 (74,000)	87,000
5F.	Lower West Fork	27,030	44,520	55,070	67,320	98,750	132,800	152,700
5G.	Village Creek	100,480	90,000	113,190	137,500	202,910	275,000	350,000
5H.	Rush Creek	21,760	22,500 (16,480)	31,500 (22,710)	41,500 (30,360)	62,500 (51,850)	81,000 (70,000)	120,000
5I.	Walker Branch	15,360	30,060	33,900	38,610	51,110	65,000	82,500
5J.	Big Fossil Creek	36,480	40,000 (29,070)	47,500 (37,120)	60,000 (47,000)	85,000 (73,960)	110,000 (98,500	150,000
5K.	Little Fossil Creek	12,160	29,000 (17,980)	36,000 (21,290)	41,500 (25,340)	52,000 (37,230)	62,500 (47,000)	78,000
5L.	Marine Creek	14,720	27,440	32,790	39,340	56,670	70,000	85,000
5M.	Middle West Fork	22,120	36,420	45,050	55,070	80,790	108,600	124,900
5N.	Sycamore Creek	24,960	96,260	109,350	124,170	157,820	190,000	230,000
5P.	Farmers Branch	8,320	23,090	27,380	32,660	43,900	52,000	64,000
5Q.	Clear Fork Trinity	306,560	155,760	178,590	206,010	275,670	310,000	365,000
5R.	Mary's Creek	27,520	7,280	9,200	11,550	18,070	25,000	30,000
5S.	Upper West Fork	1,111,170	110,450	132,030	158,080	220,320	241,000	308,400
5T.	Big Sandy Creek	229,760	8,280	8,810	9,710	11,520	15,100	17,500
	Subtotals	2,246,640	927,230 (875,950)	1,143,370 (1,079,250)	1,406,400 (1,299,830)	1,985,280 (1,850,290)	2,476,900 (2,280,500)	3,129,000
Brazos River Watershed - Parker County								
6A.	Brazos River Portion of Parker County	277,610	5,580	5,600	5,630	5,680	5,700	5,800
	Subtotal	277,610	5,580	5,600	5,630	5,680	5,700	5,800
Brazos River Watershed - Johnson County								
7A.	Brazos River Portion of Johnson County	78,750	1,300	1,300	1,310	1,320	1,400	1,400
	Subtotal	78,750	1,300	1,300	1,310	1,320	1,400	1,400
Nolands River Watershed								
8A.	Nolands River	157,150	24,690	26,590	29,330	37,320	42,500	47,500
	Subtotal	157,150	24,690	26,590	29,330	37,320	42,500	47,500
Richland Creek Watershed								
9A.	Richland Creek Portion of Ellis County	8,200	250	250	250	250	300	300
	Subtotal	8,200	250	250	250	250	300	300
Chambers-Waxahachie Creeks Watershed								
10A.	Chambers Creek	411,600	14,330	14,450	15,050	16,030	18,600	23,600
10B.	Waxahachie Creek	115,640	31,220 (27,170)	37,040 (29,840)	43,800 (33,400)	55,840 (42,870)	70,700 (58,600)	96,200
	Subtotals	527,240	45,550 (41,500)	51,490 (44,290)	58,850 (48,450)	71,870 (58,900)	89,300 (77,200)	119,800
Cummins Creek Watershed								
11A.	Cummins Creek Portion of Ellis County	13,500	400	400	400	400	400	400
	Subtotal	13,500	400	400	400	400	400	400
Sabine River Watershed								
12A.	Sabine River Portion of Kaufman, Rockwall, and Collin Counties	72,000	5,550 (4,910)	6,920 (5,860)	9,090 (7,130)	12,460 (10,230)	15,300 (13,400)	17,900
	Subtotals	72,000	5,550 (4,910)	6,920 (5,860)	9,090 (7,130)	12,460 (10,230)	15,300 (13,400)	17,900
	Totals	7,193,000	2,696,150 (2,556,170)	3,225,790 (3,016,480)	3,866,170 (3,472,290)	5,314,090 (4,527,100)	6,394,700 (5,429,300)	7,804,000
Study Area Population(3)		7,035,400	2,688,920 (2,548,940)	3,218,250 (3,008,940)	3,858,280 (3,464,400)	5,304,720 (4,517,730)	6,384,000 (5,418,600)	7,792,100

TABLE V-3. PROJECTED SEWERED POPULATION IN THE NCTCOG STUDY AREA

Node No.[1]	Location	1970	1975	1980	1990	2000	2020
TRINITY RIVER WATERSHED 1							
1A-211	Kerens	1,350	1,600	1,700	1,960	2,200	2,500
1A-239	NIPAK, Inc.	0	0	0	0	0	0
1B-92	Ennis North	2,900	3,600	4,500	5,600	7,000	9,300
1B-92	Sonoma	600	700	800	1,000	1,200	1,800
1C-91	Palmer	740	890	1,020	1,360	1,900	3,500
1C-91	Middle Red Oak Creek	0	2,280	2,600	3,730	5,300	10,400
1C-91E	Lower Red Oak Creek	0	6,520	8,290	12,780	18,100	34,300
1C-174	Cedar Hill	2,200	5,300	8,100	20,000	30,000	46,500
1D-145	Wilmer	2,700	4,600	5,900	9,200	12,800	20,100
1D-163	Ferris	1,900	2,200	2,400	3,000	3,600	5,300
1D-167	Lancaster	13,800	16,750	27,000	33,500	39,900	55,700
1D-167A	Upper Red Oak Creek	0	3,110	4,090	6,330	9,300	17,000
1D-169	De Soto	5,700	12,900	19,000	33,000	49,700	83,600
1D-170	Woodland Hills	0	960	1,300	2,600	3,600	5,600
1D-173	Duncanville	13,200	20,800	28,000	41,000	59,800	92,900
1F-146	Prairie Creek	54,900	65,000	75,850	92,070	117,400	148,700
1F-146	Elam Creek	15,400	18,600	20,400	23,000	25,700	32,400
1F-146	Five Mile Creek	94,300	128,800	140,600	189,000	217,100	256,700
1E-147	Kleberg	4,200	6,900	9,000	13,400	18,300	27,600
1E-149	Balch Springs	9,000	11,600	13,300	16,900	19,400	31,600
1E-150	Seagoville Fed. Cor. Inst.	700	700	700	700	700	700
1G-143	Hutchins	1,600	2,500	3,100	4,600	6,000	9,000
1H-64	Plano (White Rock Creek)	0	10,000	20,000	35,000	42,600	51,200
1H-66	Richardson - Floyd Branch	14,460	15,000	16,000	17,000	18,000	18,000
1H-233	Richardson (Cottonwood Creek)	29,000	31,000	33,000	36,500	36,500	36,500
1H-235	Upper White Rock Creek	16,700	24,000	33,400	45,700	56,300	59,100
1H-236	Middle White Rock Creek	35,700	46,800	54,500	70,200	86,700	108,800
1H-236A	Lower White Rock Creek	150,400	183,000	199,000	223,000	245,000	270,000
1I-175	Dallas Plant Area	245,000	295,300	314,700	349,600	384,400	409,300
1I-175	Coombs Creek	186,100	227,300	248,100	278,300	296,500	306,100
1I-175	Fair Park Area	92,400	101,700	102,900	103,200	103,200	103,200
1I-175	Procter & Gamble, Inc.	0	0	0	0	0	0
	Subtotal	994,950	1,250,510	1,399,250	1,673,230	1,918,200	2,257,500
CEDAR CREEK-WATERSHED 2							
2A-202	Mabank	1,050	1,350	1,390	1,510	1,600	1,900
2A-203	Malakoff	1,700	2,020	2,230	2,700	3,500	4,800
2A-204	Athens (North)	4,040	4,440	4,890	5,930	7,700	10,500
2A-205	Athens (West)	6,740	7,400	8,150	9,890	13,800	17,500
2A-208	Trinidad	1,080	1,520	1,670	2,030	2,600	3,600
2A-208	Cedar Creek Lake Area	0	3,880	4,240	4,970	6,600	9,700
2B-191	Wills Point	2,400	2,450	2,500	2,600	2,700	2,800
2C-192	Terrell (Kings Creek)	14,000	16,000	17,000	19,000	21,000	22,500
2C-193	Terrell (Bachelor Creek)	1,500	1,600	2,000	5,000	11,000	22,500
2C-196	Kaufman	4,900	5,000	5,200	6,000	6,700	8,100
2C-199	Kemp	800	890	940	1,000	1,100	1,200
	Subtotal	38,210	46,550	50,210	60,630	78,300	105,100
EAST FORK TRINITY-WATERSHED 3							
3A-57	North Seagoville Area	0	4,300	6,100	9,700	14,900	21,800
3A-58	Seagoville	4,210	5,800	7,600	11,400	15,700	27,500
3A-61	Crandall	680	800	880	1,100	1,300	2,000
3B-15	Farmersville	1,850	2,250	2,300	2,400	2,500	2,700
3B-16	Rockwall	4,500	8,500	14,000	23,000	32,000	34,400
3B-20	Heath	0	1,000	3,900	5,000	7,000	10,000
3B-51	Forney	1,600	1,830	2,140	2,960	3,800	5,500
3C-49	Long Creek	0	2,200	3,200	5,200	7,600	12,400
3C-53	North Mesquite Creek	0	6,940	11,700	19,500	26,700	41,900
3C-54	Mesquite	55,000	63,100	72,200	90,700	117,800	126,000
3D-23	Sunnyvale	0	6,900	12,000	39,600	42,500	42,500
3D-45	Garland (Lower Rowlett Creek)	0	2,000	5,000	12,000	12,000	12,000
3D-45	Garland (Lower Duck Creek)	0	3,000	10,000	18,800	18,800	18,800
3D-67	Richardson (Duck Creek)	3,850	5,000	8,000	15,000	20,000	25,700
3D-67A	Garland (Upper Duck Creek)	38,600	43,000	49,000	61,900	61,900	61,900
3D-67B	Garland (Middle Duck Creek)	19,000	24,000	30,000	48,000	48,000	48,000
3D-67B	Mesquite and Dallas (Duck Creek)	1,330	3,200	4,800	4,800	4,800	4,800
3E-25	Allen	1,800	3,700	9,400	38,800	71,900	88,800
3E-26	Plano (Rowlett Creek)	4,500	12,800	31,200	69,400	82,700	89,800
3E-31	Richardson (Rowlett Creek)	0	860	2,900	8,100	17,200	20,100
3E-33	Garland (Spring Creek)	3,170	8,700	14,500	40,900	44,300	44,300
3E-35	Sachse	0	3,660	6,400	14,500	18,200	18,300
3E-40	Rowlett (Rowlett Creek)	440	1,000	1,500	3,400	7,500	10,500
3E-40	Rowlett (Muddy Creek)	440	1,000	1,500	3,400	7,500	10,500
3E-40	Garland (Rowlett Creek)	14,000	21,000	30,000	47,000	50,000	52,000
3F-65	Richardson (Spring Creek)	5,800	8,600	12,800	24,900	27,000	27,000
3F-69	Plano (Spring Creek)	13,500	23,900	52,400	90,200	91,500	91,500
3G-34	Wylie	2,890	3,600	4,500	6,200	8,600	13,500
3H-1	Anna	450	600	600	600	600	600
3H-3	McKinney (North)	0	0	0	0	0	0
3H-24	McKinney (South)	16,600	19,400	22,300	33,600	56,400	70,000
3I-0	Van Alstyne	1,700	1,900	2,050	2,400	2,900	3,800
3I-5	Princeton	680	900	1,000	1,330	1,700	2,500
3J-7	Tom Bean	400	400	400	400	400	400
3J-8	Blue Ridge	290	350	360	390	400	500
3J-11	Trenton	800	840	870	950	1,000	1,100
3J-14	Leonard	1,070	1,180	1,230	1,340	1,500	1,500
	Subtotal	199,150	298,210	438,730	758,870	928,600	1,044,600
ELM FORK TRINITY-WATERSHED 4							
4A-81	Lewisville	10,000	15,000	23,000	38,000	46,000	68,000
4A-112	Grapevine Creek	0	2,500	9,100	37,000	59,000	68,600
4A-114	Hackberry Creek	0	3,000	13,800	55,600	84,500	101,000
4A-117	Carrollton	17,000	27,000	36,000	56,000	61,000	70,000
4A-120	Farmers Branch	26,000	27,000	32,000	37,000	43,000	55,000
4A-122	Dallas (California Crossing)	5,100	5,200	5,700	6,600	7,700	10,000
4A-124	Irving (Delaware Creek)	90,000	100,350	117,580	121,350	130,100	149,800
4A-163	Coppell	0	1,930	5,560	20,100	30,000	34,200

Node No.[1]	Location	1970	1975	1980	1990	2000
ELM FORK TRINITY - WATERSHED 4, continued						
4B-150	Justin	1,250	1,350	1,500	2,250	3,80
4B-151	Roanoke	610	650	700	800	90
4B-156	Grapevine	8,000	25,000	40,000	54,000	60,00
4B-159	Future Development	0	100	130	200	30
4B-161	Future Development	0	100	130	200	30
4C-50	Muenster	1,300	1,450	1,700	2,000	2,50
4C-51	Myra	110	110	120	180	20
4C-54	Lindsay	310	330	350	380	40
4C-55	Gainesville	15,660	17,050	18,500	21,600	23,10
4C-58	Valley View	830	900	1,000	1,250	1,60
4C-70A	Lake Dallas	800	900	1,100	1,400	1,90
4C-71	Denton	40,000	51,000	62,000	76,000	95,00
4C-74	Camp Copass	150	180	200	280	40
4C-76	Shady Shores	120	130	160	210	30
4C-206	Prosper	320	420	430	470	50
4C-209	Frisco	2,000	2,070	2,150	2,340	2,50
4D-100	Krum	450	500	600	850	1,00
4D-104	Argyle	250	280	310	430	60
4E-2	Rosston	120	130	140	180	20
4E-3	Leo	80	90	100	110	10
4E-8	Bolivar	110	130	150	200	30
4E-10	Sanger	1,800	2,000	2,400	3,000	3,80
4F-60	Pilot Point	2,100	2,300	2,700	3,200	3,80
4F-64	Aubrey	880	1,000	1,250	1,700	2,30
4F-200	Gunter	440	640	690	820	1,00
4F-204	Celina	1,400	1,670	1,730	1,880	2,00
4G-213	Collinsville	540	580	630	750	90
4G-214	Tioga	430	450	480	570	70
	Subtotal	228,160	293,490	384,090	548,900	671,70
BIG BEAR CREEK AND LITTLE BEAR CREEK-WATERSHEDS 5A AND 5B						
5A-19	Regional Airport	0	24,070	33,040	40,000	44,40
5A-20	Keller	1,160	2,880	3,850	5,980	7,60
5A-21	Southlake	820	1,220	1,680	4,280	6,30
5A-22	Southlake	820	1,220	1,680	4,280	6,30
5A-23	Colleyville	1,650	5,310	9,000	15,670	20,00
5A-24	Grapevine	3,500	10,900	17,450	23,600	26,10
5A-30	Irving	600	3,750	6,310	14,140	21,30
5A-60	Greenview	400	410	430	450	50
5B-25	N. Richland Hills	1,500	2,000	2,500	3,500	4,50
5B-26	Hurst	3,500	4,000	4,500	5,000	5,50
5B-27	Bedford	500	1,000	1,500	2,500	3,50
5B-28	Colleyville	0	0	0	0	3,00
5B-29	Euless	4,350	9,000	13,000	14,500	16,00
	Subtotal	18,800	65,760	94,940	133,900	165,00
WATERSHEDS 5C, 5D, 5E, 5F						
5C-1	Venus	370	390	400	450	50
5C-65	Grand Prairie	31,200	36,890	45,240	60,430	74,90
5C-208	East Mountain Creek	300	2,610	3,070	4,010	5,20
5C-211	East Mountain Creek	200	3,770	6,430	11,760	19,40
5C-350	Kirby Creek	30,880	37,290	42,650	53,960	63,00
5C-450	Future Development	70	450	4,480	8,970	11,20
5C-451	Future Development	210	1,410	2,830	5,650	35,30
5C-452	Future Development	230	1,530	15,280	30,560	38,20
5C-453	Future Development	100	640	6,400	12,800	16,00
5C-500	Midlothian	1,640	1,940	2,350	3,440	5,30
5D-214	Mansfield	2,370	2,520	4,750	10,000	20,50
5D-448	Future Development	80	560	5,550	11,100	13,80
5D-449	Future Development	60	410	4,140	8,280	10,40
5E-195	Arlington	47,900	56,830	77,290	113,190	151,40
5F-184	Euless (West)	8,730	22,890	34,050	56,890	84,30
5F-186	Arlington	4,360	5,170	7,030	10,290	13,80
5F-188	Euless (East)	2,180	4,230	8,500	18,190	32,00
5F-190	Arlington	4,360	5,170	7,030	10,290	13,80
	Subtotal	135,240	184,700	277,470	430,260	609,
WEST FORK TRINITY-WATERSHED 5						
5G-123	Fort Worth	48,990	63,030	79,750	105,800	117,
5G-130	Burleson	2,930	3,240	3,500	4,100	5,
5G-132	Crowley	1,060	1,980	3,000	5,980	7,
5G-134	Fort Worth	29,390	37,820	47,870	63,480	70,
5G-136	Everman	2,320	3,780	4,850	5,490	5,
5G-137	Kennedale	1,740	5,850	9,000	13,890	21,
5G-138	Forest Hill	4,110	6,750	9,500	16,960	22,
5H-141	Banfield Mobile Home Park	110	300	600	1,600	2,
5H-143	Royal Coach Mobile Home Park	950	1,050	1,700	4,000	8,
5H-145	L & M Mobile Home Park	90	100	150	700	1,
5H-146	Dalworthington Gardens	1,100	1,980	2,800	4,850	5,
5H-149	Treetop Mobile Home Park	350	400	700	2,200	6,
5H-150	Treetop Mobile Home Park	910	950	1,200	2,700	6,
5H-153	Tumbleweed Mobile Home Park	610	1,000	1,800	4,400	8,
5H-156	Wilson	40	300	700	2,150	4,
5H-157	Parsons	50	300	1,000	3,400	8,
5H-158	Pantego	1,140	2,430	2,800	4,850	5,
5H-199	Arlington	8,710	10,330	14,050	20,580	27,
5H-200	Arlington	8,710	10,330	14,050	20,580	27,
5I-117	N. Richland Hills	12,480	17,280	25,000	31,500	35,
5I-117	Watauga	970	3,420	5,150	7,920	9,
5I-117	Hurst	4,210	11,160	16,250	24,230	31,
5I-118	Hurst	12,290	32,590	47,450	70,750	91,
5I-168	Richland Hills	4,350	5,090	5,880	7,270	7,
5J-112	Richland Hills	4,350	5,090	5,880	7,270	7,
5J-113	Haltom City	25,640	41,670	53,000	70,910	90,
5K-166	Saginaw	1,650	2,880	6,000	10,800	10,
5K-167	Bluemound	1,260	2,430	2,850	3,550	3,
5M-92	Fort Worth	48,990	63,030	79,750	105,800	117,
5M-92	Fort Worth	29,390	37,820	47,870	63,480	70,
5M-123	Fort Worth	88,180	113,460	143,620	190,440	212,

BLE V-3. PROJECTED SEWERED POPULATION IN THE NCTCOG STUDY AREA

ED 4, continued

	1970	1975	1980	1990	2000	2020
	1,250	1,350	1,500	2,250	3,800	5,000
	610	650	700	800	900	1,200
	8,000	25,000	40,000	54,000	60,000	70,000
	0	100	130	200	300	500
	0	100	130	200	300	500
	1,300	1,450	1,700	2,000	2,500	4,000
	110	110	120	180	200	300
	310	330	350	380	400	500
	15,660	17,050	18,500	21,600	23,100	28,000
	830	900	1,000	1,250	1,600	2,300
	800	900	1,100	1,400	1,900	2,700
	40,000	51,000	62,000	76,000	95,000	120,000
	150	180	200	280	400	600
	120	130	160	210	300	500
	320	420	430	470	500	600
	2,000	2,070	2,150	2,340	2,500	2,700
	450	500	600	850	1,000	1,500
	250	280	310	430	600	800
	120	130	140	180	200	300
	80	90	100	110	100	200
	110	130	150	200	300	500
	1,800	2,000	2,400	3,000	3,800	4,800
	2,100	2,300	2,700	3,200	3,800	5,200
	880	1,000	1,250	1,700	2,300	3,000
	440	640	690	820	1,000	1,300
	1,400	1,670	1,730	1,880	2,000	2,400
	540	580	630	750	900	1,200
	430	450	480	570	700	1,000
Subtotal	228,160	293,490	384,090	548,900	671,700	818,200

BEAR CREEK-WATERSHEDS 5A AND 5B

	1970	1975	1980	1990	2000	2020
	0	24,070	33,040	40,000	44,400	49,000
	1,160	2,880	3,850	5,980	7,600	8,000
	820	1,220	1,680	4,280	6,300	10,000
	820	1,220	1,680	4,280	6,300	10,000
	1,650	5,310	9,000	15,670	20,000	30,000
	3,500	10,900	17,450	23,600	26,100	30,500
	600	3,750	6,310	14,140	21,300	31,200
	400	410	430	450	500	500
s	1,500	2,000	2,500	3,500	4,500	6,000
	3,500	4,000	4,500	5,000	5,500	6,000
	500	1,000	1,500	2,500	3,500	6,000
	0	0	0	0	3,000	6,500
	4,350	9,000	13,000	14,500	16,000	18,000
Subtotal	18,800	65,760	94,940	133,900	165,000	211,700

F

	1970	1975	1980	1990	2000	2020
	370	390	400	450	500	800
	31,200	36,890	45,240	60,430	74,900	97,900
eek	300	2,610	3,070	4,010	5,200	7,900
eek	200	3,770	6,430	11,760	19,400	27,000
	30,880	37,290	42,650	53,960	63,800	84,100
nt	70	450	4,480	8,970	11,200	17,900
nt	210	1,410	2,830	5,650	35,300	56,500
nt	230	1,330	15,280	30,560	38,200	61,100
nt	100	640	6,400	12,800	16,000	25,600
	1,640	1,940	2,350	3,440	5,300	12,500
	2,370	2,520	4,750	10,000	20,500	50,000
nt	80	560	5,550	11,100	13,900	22,200
nt	60	410	4,140	8,280	10,400	14,600
	47,900	56,830	77,290	113,190	151,400	206,400
	8,730	22,890	34,050	56,890	84,300	159,900
	4,360	5,170	7,030	10,290	13,800	18,800
	2,180	4,230	8,500	18,190	32,000	76,000
	4,360	5,170	7,030	10,290	13,800	18,800
Subtotal	135,240	184,700	277,470	430,260	609,900	960,000

HED 5

	1970	1975	1980	1990	2000	2020
	48,990	63,030	79,750	105,800	117,800	140,600
	2,930	3,240	3,500	4,100	5,800	8,500
	1,060	1,980	3,000	5,980	7,600	9,000
	29,390	37,820	47,870	63,480	70,700	84,400
	2,320	3,780	4,850	5,490	5,500	5,500
	1,740	5,850	9,000	13,890	21,000	40,000
	4,110	6,750	9,500	16,960	22,500	30,000
Home Park	110	300	600	1,600	2,600	4,000
ile Home Park	950	1,050	1,700	4,000	8,500	13,000
e Park	90	100	150	700	1,300	2,100
Gardens	1,100	1,980	2,800	4,850	5,100	5,700
Home Park	350	400	700	2,200	6,000	10,400
Home Park	910	950	1,200	2,700	6,300	10,800
le Home Park	610	1,000	1,800	4,400	8,000	11,700
	40	300	700	2,150	4,500	8,200
	50	300	1,000	3,400	8,000	12,400
	1,140	2,430	2,800	4,850	5,300	6,500
	8,710	10,330	14,050	20,580	27,500	37,500
	8,710	10,330	14,050	20,580	27,500	37,500
ls	12,480	17,280	25,000	31,500	35,000	65,000
	970	3,420	5,150	7,920	9,200	10,200
	4,210	11,160	16,250	24,230	31,300	42,500
	12,290	32,590	47,450	70,750	91,300	124,100
	4,350	5,090	5,880	7,270	7,300	7,300
	4,350	5,090	5,880	7,270	7,300	7,300
	25,640	41,670	53,000	70,910	90,000	140,000
	1,650	2,880	6,000	10,800	10,800	10,800
	1,260	2,430	2,850	3,550	3,600	3,600
	48,990	63,030	79,750	105,800	117,800	140,600
	29,390	37,820	47,870	63,480	70,700	84,400
	88,180	113,460	143,620	190,440	212,000	253,100

Node No.[1]	Location	1970	1975	1980	1990	2000	2020
WEST FORK TRINITY - WATERSHED 5, continued							
5N-94	Edgecliff	630	5,310	6,700	7,270	7,300	7,300
5N-97	Fort Worth	15,600	25,210	31,920	42,320	47,100	56,300
5N-98	Fort Worth	19,600	25,310	31,920	42,320	47,100	56,300
5N-99	Fort Worth	29,390	37,820	47,870	63,480	70,700	84,400
5N-100	Fort Worth	39,190	50,430	63,830	84,640	94,200	112,500
5N-100	Fort Worth	39,190	50,430	63,830	84,640	94,200	112,500
5Q-71	Benbrook	6,390	11,610	15,000	25,360	25,500	35,000
5Q-72	St. Francis Village	1,050	1,200	1,350	1,500	1,700	2,000
5Q-73	Weatherford	17,500	18,500	20,000	22,020	26,200	37,000
5Q-75	Lake Weatherford	1,300	1,330	1,330	1,350	1,400	1,500
5Q-76	Aledo	410	410	420	430	500	500
5S-18	Chico	700	730	750	800	900	1,200
5S-19	Bridgeport	4,150	4,900	5,400	6,900	8,000	11,000
5S-23	Runaway Bay	530	1,250	1,500	2,000	2,500	4,000
5S-25	Wizard Wells	70	70	80	80	100	100
5S-35	Jermyn	1,100	1,150	1,150	1,180	1,200	1,300
5S-38	Jacksboro	4,200	4,300	4,400	4,600	4,900	5,500
5S-39	Decatur	4,100	4,750	5,100	6,200	7,400	9,500
5S-43	Paradise	400	450	530	600	700	1,000
5S-46	Boyd	670	710	760	870	970	1,300
5S-46	Aurora	100	100	100	100	100	100
5S-46	Rhome	420	460	500	590	700	1,000
5S-47	Newark	540	610	700	950	1,100	1,500
5S-51	Reno	80	80	90	100	100	100
5S-51A	La Junta	510	650	750	830	900	1,300
5S-51A	Highland Addition .	400	480	550	650	800	900
5S-52	Springtown	1,150	1,250	1,400	1,600	1,900	[illegible]
5S-59	Lakeside	970	2,880	3,750	5,650	7,100	8,500
5S-60	Lake Worth	5,810	6,300	8,000	11,470	14,000	20,000
5S-63	Sansom Park	4,260	6,300	7,250	8,360	8,600	8,600
5S-69	Westover Hills	390	990	990	990	1,000	1,000
5S-69	River Oaks	8,230	8,700	8,700	8,700	8,700	8,700
5S-70	Westworth Village	2,900	3,420	4,000	4,800	4,800	4,800
5S-70	White Settlement	11,610	14,580	17,000	21,810	25,500	30,000
5S-175	Azle	3,290	6,300	9,000	10,500	22,000	45,000
5T-1	Bowie	6,760	7,940	8,940	10,570	12,000	15,000
5T-4	Lake Amon G. Carter	510	630	730	900	1,200	1,900
5T-6	Sunset	190	200	230	300	400	800
5T-9	Park Springs	60	70	70	70	70	100
5T-11	Alvord	740	750	760	780	800	1,000
	Subtotal	582,160	796,400	1,015,070	1,288,910	1,602,140	2,059,700
CHAMBERS CREEK,WAXAHACHIE CREEK - WATERSHED 10							
10A-80	Alvarado	1,660	1,890	1,960	2,180	2,600	3,500
10A-81	Maypearl	360	380	390	410	500	500
10A-83	Grandview	1,060	1,150	1,170	1,240	1,400	1,800
10A-84	Italy	1,400	1,640	1,650	1,680	1,700	2,000
10A-86	Milford	400	480	490	500	500	600
10A-97	Corsicana*	22,900	24,400	26,100	30,100	34,000	43,000
10A-99	Forreston	250	350	350	350	400	400
10B-89	Waxahachie	17,000	21,000	25,000	31,500	40,000	50,000
10B-544	Bardwell	200	230	250	270	300	300
	Subtotal*	22,330	27,120	31,260	38,130	47,400	59,100
CUMMINS CREEK - WATERSHED 11							
11A-94	Ennis	8,800	11,400	13,500	17,400	21,000	27,800
	Subtotal	8,800	11,400	13,500	17,400	21,000	27,800
SABINE RIVER - WATERSHED 12							
12A-18	Royse City	1,700	2,400	4,000	5,900	9,400	12,000
12A-501	Josephine	300	400	500	700	900	1,000
	Subtotal	2,000	2,800	4,500	6,600	10,300	13,000
	Study Area Totals*	2,229,800	2,976,940	3,709,020	4,956,830	6,052,540	7,556,700

*Corsicana is outside the study area, and its population is not included in watersheds subtotals or study area totals.

(1) Node numbers shown apply to existing and potential sewage treatment plants and major loading points, and may include population from adjacent watersheds as indicated by location.

transportation or other factors. Under such controlled conditions, the population distribution projected herein should be adjusted as applicable.

WATER CONSUMPTION

Available municipal water consumption and sewage flow data were obtained in the 1968 inventory by Forrest and Cotton, Inc. and Freese, Nichols and Endress, which is described in Chapter III. These data, together with more recently obtained data, provide the broadest and most reliable basis for estimating present average daily sewage flows. Water supply data for all of the cities were utilized to determine the present average daily water consumption rates in the study area.

Water consumption consists of the total amount of water used by residences, commercial establishments, industries, etc. The total quantity of water used in the study area in 1967 was estimated in the inventory to be about 274 million gallons per day (mgd) as shown on Fig. V-2. To obtain the average per capita usage, this quantity was divided by an estimated population of 2,186,000 (as developed from the 1967 Inventory data), the approximate total number of people served by existing municipal water systems. The resulting average daily water consumption was about 126 gallons per capita per day (gpcd) in the study area as shown on Fig. V-3.

Based on Texas Water Plan projections of water use in the area, it is estimated that future consumption will increase at an average rate of about 1 percent per year through the year 2020. This increase appears reasonable and in line with those anticipated in other parts of the country and reflects a greater use of water-consuming devices such as lawn sprinklers, air conditioners, automatic washing machines, garbage disposal units and dishwashers. It is thus anticipated that per capita water consumption may approach 200 gpcd by the year 2020.

During the 1967 to 2020 period, the total population served with water within the study area is expected to increase from about 2,186,000 to 7,557,000. Therefore, total water consumption is expected to increase from 274 mgd to about 1,510 mgd. The estimated total water requirement for the study area in the year 2020, as presented in The Texas Water Plan, is about 1,400 mgd.

SEWAGE FLOW

Total sewage flow is made up of three components based on source: sanitary sewage, industrial wastewater, and infiltration. Each of these components must be evaluated separately to establish a sound basis for present and future estimates of flow. The flow records of existing sewage treatment plants were gathered in the inventory prepared by Forrest and Cotton, Inc. and Freese, Nichols and Endress for NCTCOG in 1968. An additional inventory of major wastewater treatment plants was conducted in this study to provide current information as discussed in Chapter IV. Complete questionnaires resulting from the latter inventory are presented in Appendix B and have been utilized to determine the average daily per capita sanitary sewage flows. The amounts of wastewater contributed by residential population, industrial and commercial establishments and infiltration are included in the sewage flows recorded on the questionnaires.

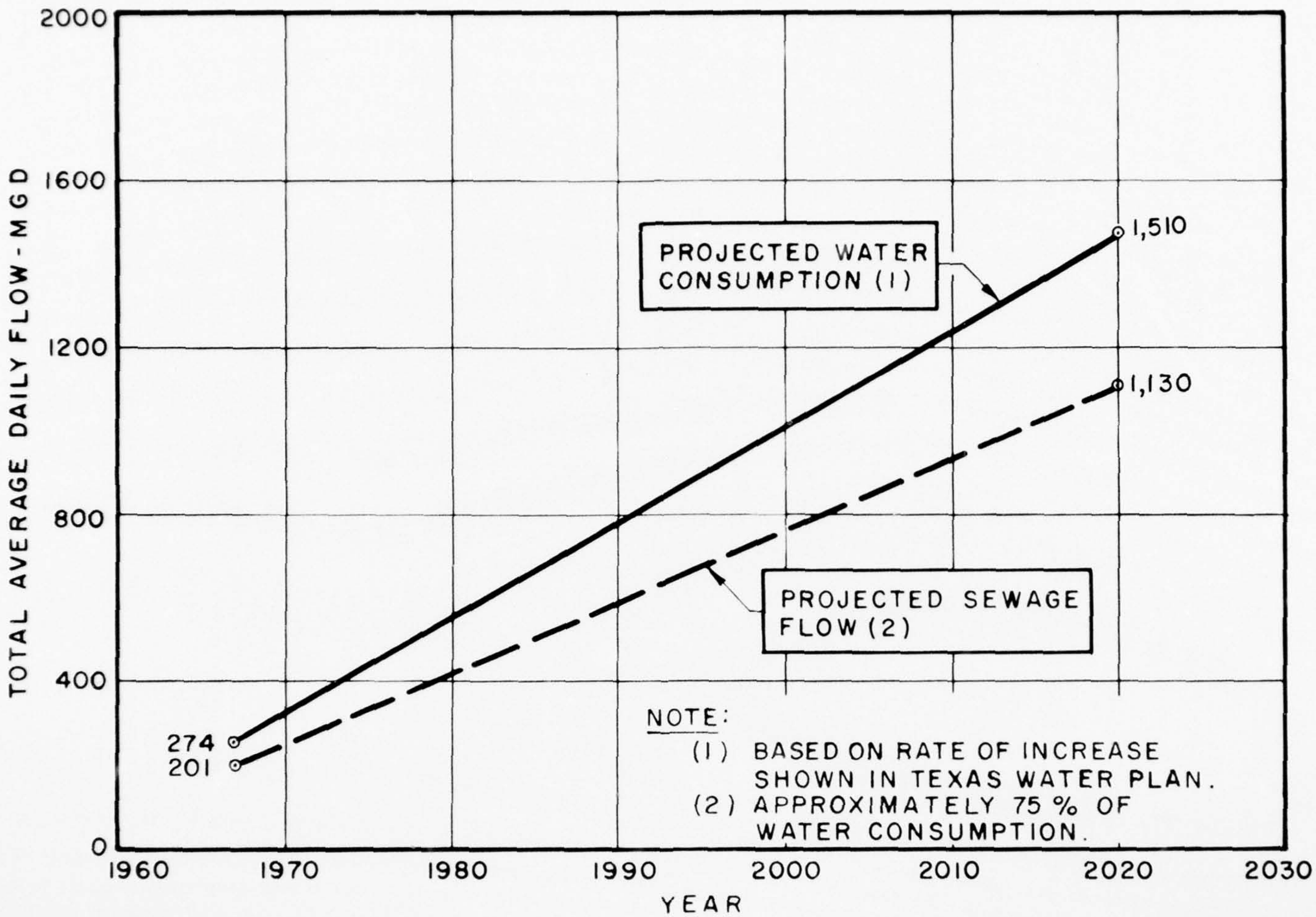
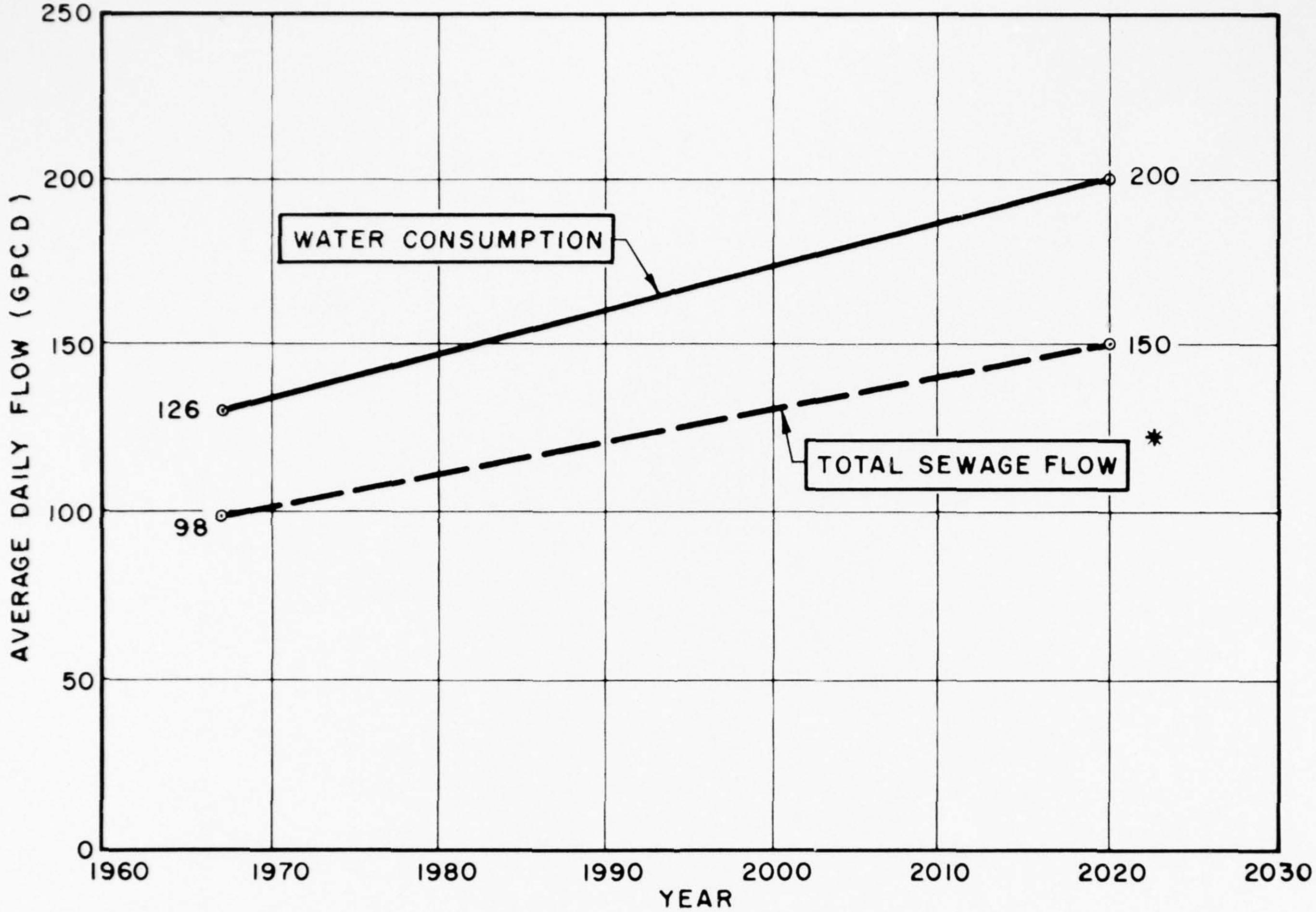


FIG. V-2 PROJECTED TOTAL WATER CONSUMPTION AND SEWAGE FLOW FOR STUDY AREA



* INCLUDING INDUSTRIAL WASTEWATER

FIG. V-3 PROJECTED AVERAGE WATER CONSUMPTION AND SEWAGE FLOW FOR STUDY AREA

The estimated average daily quantity of sewage discharged in 1967 from sewered portions of the study area was about 201 mgd as shown on Fig. V-2. This quantity was divided by an estimated sewered population of about 2,044,000, the approximate number of people served by existing municipal sewerage systems in 1967. The resulting estimated average daily sewage discharge was 98 gpcd in the study area as shown on Fig. V-3. This represents about 78 percent of the average daily per capita water consumption, and consists of the sum of used water actually returned to the sewers including sanitary sewage from residential and employment populations, industrial wastewater, and infiltration. Average annual infiltration is estimated to be about 20 percent of the total annual sewage flow.

The projected population served by sewers in the year 2020 is expected to be about 7,557,000 which is the same as projected for the population expected to be served with water. It is considered reasonable to assume that about 75 percent of the water consumption will represent the sewage flow through the year 2020. On this basis the average per capita sewage flow for municipal systems is expected to increase from 98 gpcd to 150 gpcd, based on residential population served, by the end of the study period as shown on Fig. V-3. This will result in an increase in estimated average sewage flow from 201 mgd to 1130 mgd as shown on Fig. V-2.

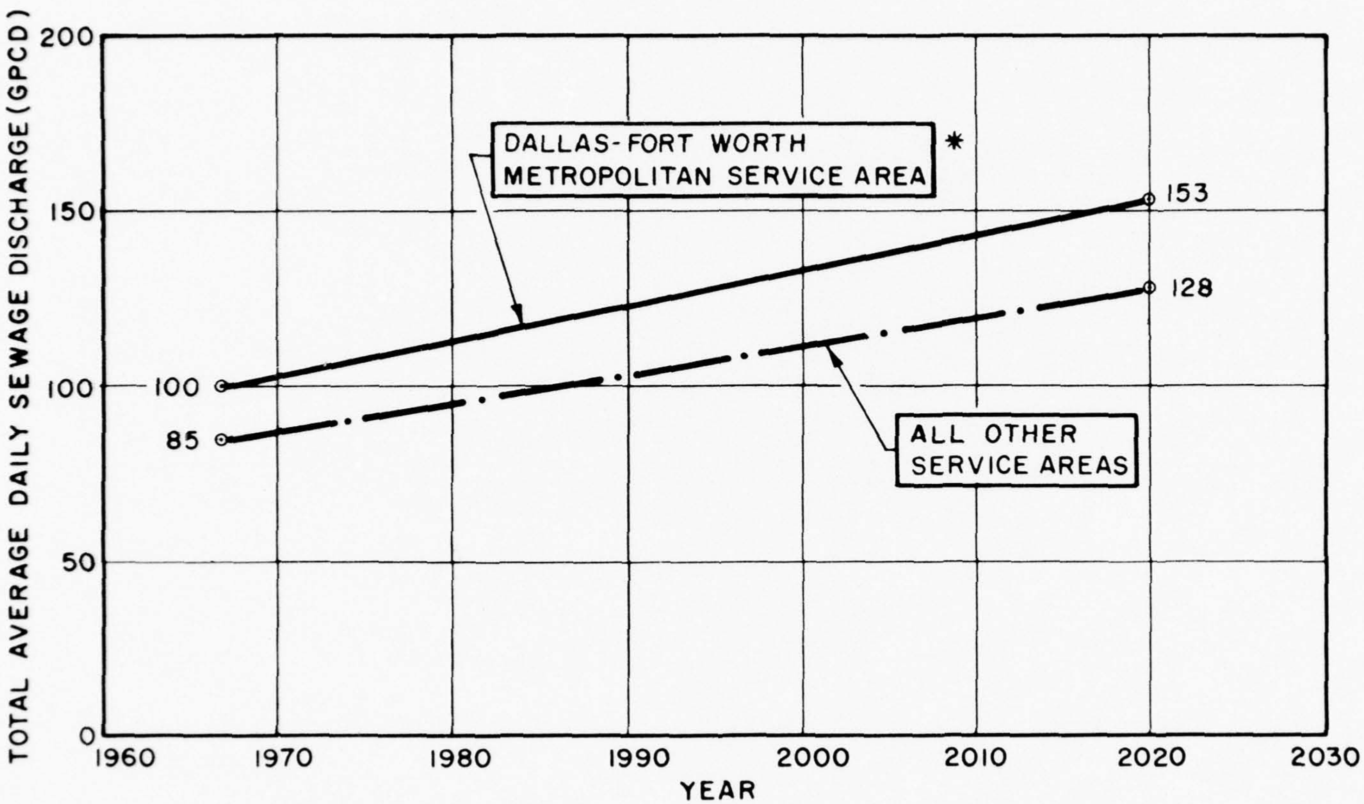
The average sewage flows to treatment plants serving the individual cities in the study area vary widely. To develop rational criteria for this study it was considered that the above sewage flows apply to residential population only, and have divided these flows into two categories: flows characteristic of the Dallas-Fort Worth metropolitan service area and flows characteristic of all other service areas. These service areas are discussed in terms of watersheds and joint systems in Chapters IX and X. The estimated 1967 average sewage discharges for these two categories were 100 gpcd and 85 gpcd, respectively, as shown on Fig. V-4.

PEAK SEWAGE FLOWS

The relation of maximum and minimum domestic sewage discharges (including sanitary sewage from residential and employment population and normal industrial wastewater) to the average daily discharges which have been used for this study is shown on Fig. V-5. The curves shown on the figure were derived from records and extensive flow measurements by Camp, Dresser & McKee in a large number of municipalities. These curves have been published in the recently revised ASCE Manual 37 (WPCF Manual No. 9) on the "Design and Construction of Sanitary and Storm Sewers." They are not applicable for small areas where the average rate of discharge is less than 0.1 mgd. For such low rates 6.0 may be used as the ratio of peak flow to average daily flow.

CHARACTERISTICS OF SANITARY SEWAGE

Sanitary sewage flow consists of all wastewaters discharged from sanitary fixtures in homes, businesses and industries. Characteristics of sanitary sewage which are commonly used to indicate its strength are concentrations of coliform bacteria, the 5-day 20°C biochemical oxygen demand (BOD) and suspended solids (SS). Additional important characteristics of sewage are pathogenic bacteria and viruses, nitrogenous BOD, settleable solids, nutrients (such as nitrogen and phosphates), chlorides and sulfates.



*BASED ON DALLAS AND TARRANT COUNTIES

FIG. V-4 FUTURE SEWAGE DISCHARGE TRENDS FOR SERVICE AREAS

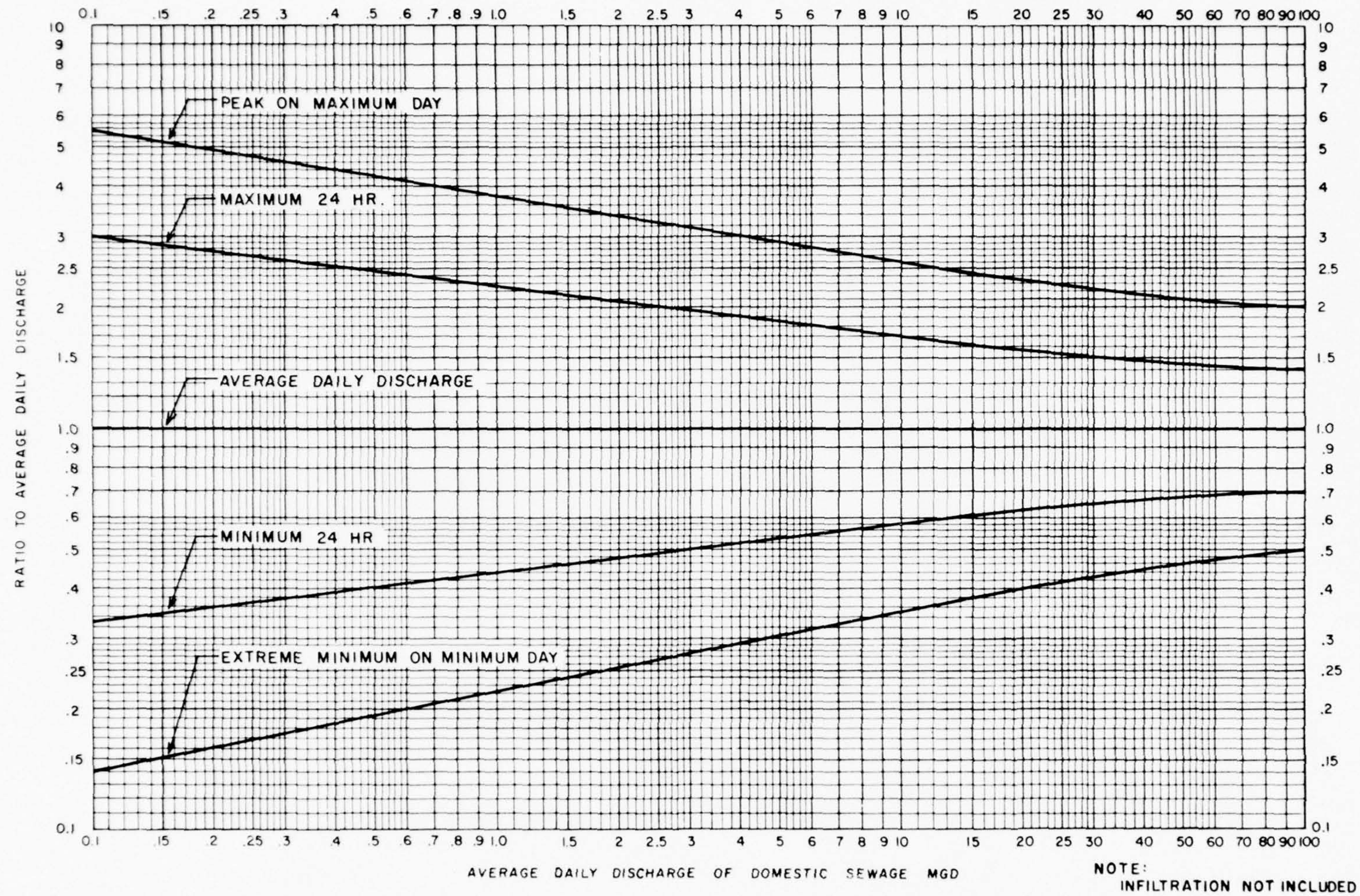


FIG. V-5 RELATION OF EXTREME DISCHARGES ON MAXIMUM AND MINIMUM DAYS TO THE AVERAGE DAILY DISCHARGE OF DOMESTIC SEWAGE

Sanitary sewage contains the waste products of man's life processes, including disease-causing organisms or pathogens. Evidence of recent pollution by sanitary sewage is considered to be indicated by the presence of fecal coliform bacteria, i.e. coliforms whose normal habitat is the lower intestines of warm-blooded animals. These coliform bacteria, while not pathogenic themselves, indicate the possible presence of disease-producing bacteria and viruses which can produce such diseases as typhoid fever and hepatitis in man.

While 100 to 400 billion fecal coliform bacteria are excreted daily per person, these bacteria die off at about the same rate as the typhoid bacillus. Because of their large numbers, fecal coliforms therefore commonly are measured as the indicator of water pollution that is dangerous to public health. The concentration of coliform bacteria is expressed in most probable number (MPN) per 100 milliliters (ml). Normal municipal sewage in dry weather contains about 50 to 300 million fecal coliforms per 100 ml.

The BOD indicates the amount of decomposable organic matter present in sewage and represents the amount of oxygen consumed in the presence of the organic matter in the wastewater. The standard measurement is the 5-day 20°C BOD (BOD). Suspended solids indicate the amount of settleable and non-settleable solids (undissolved) present in sewage.

At present about 50 percent of the households in the study area employ garbage grinders which significantly increase the BOD and SS loads contributed to treatment facilities. The majority of households may be expected to employ such units in the future.

Analyses of sewage at all existing treatment plants were summarized in the 1968 inventory, and those for 25 major plants were updated in this study as shown on the questionnaires in Appendix B. Characteristics of sewage handled by 22 major sewerage systems in the study area are summarized in Table V-4. Based on these characteristics and the expected increase in the use of garbage grinders, the future per capita BOD and SS content of sanitary sewage in the Upper Trinity River Basin has been estimated as indicated in Table V-5.

TABLE V-5

PROJECTED UNIT BOD AND SUSPENDED SOLIDS LOADINGS

	Year					
	Dallas-Fort Worth Metropolitan Service Area			All Other Service Areas		
Average Loading*	1970	1990	2020	1970	1990	2020
BOD (lb. per day per capita)	0.25	0.26	0.28	0.17	0.18	0.20
Suspended Solids (lb. per day per capita)	0.26	0.28	0.30	0.20	0.22	0.24

*Loadings are expressed in terms of residential population and include industrial waste loads.

TABLE V-4. SEWAGE CHARACTERISTICS FOR SELECTED SEWERAGE SYSTEMS(1)

Location	Estimated(2) Population Served	Average Daily Flow (mgd)	Year	Influent Quality(3)			
				BOD		SS	
				(mg/l)	(lb/day/cap)	(mg/l)	(lb/day/cap)
DALLAS-FORT WORTH METROPOLITAN SERVICE AREA							
Dallas	812,000	85.10	1967	310	0.27	340	0.30
Fort Worth	404,910	42.40	1967	300	0.26	290	0.26
Trinity River Authority Central System	172,110	13.60	1967	320	0.21	390	0.26
Arlington	67,210	5.40	1968	210	0.14	310	0.21
Euless	14,900	1.80	1968	160	0.16	260	0.26
Garland	70,300	8.00	1967	240	0.23	210	0.20
Haltom City	23,800	1.62	1969	120	0.07	130	0.08
Mesquite	51,700	4.80	1969	160	0.12	190	0.15
Richardson	43,500	4.90	1966	240	0.22	170	0.16
Rockwall	1,010	0.14	1963	180	0.21	120	0.14
OTHER SERVICE AREAS							
Athens	9,300	1.19	1967	90	0.10	150	0.16
Cleburne	19,700	1.89	1969	380	0.30	300	0.24
Denton	37,400	3.22	1967	370	0.27	520	0.38
Ennis	10,550	0.75	1968	180	0.11	130	0.08
Gainesville	19,800	1.39	1966	180	0.11	160	0.09
Kaufman	4,800	0.17	1968	290	0.09	414	0.14
Lewisville	8,000	0.40	1968	200	0.08	200	0.08
McKinney	15,700	1.50	1968	250	0.20	130	0.10
Plano	15,180	1.55	1967	150	0.13	60	0.05
Terrell	12,280	2.00	1965	470	0.64	300	0.41
Waxahachie	13,750	0.95	1968	210	0.12	210	0.12
Weatherford	13,900	0.75	1969	330	0.15	150	0.07

Notes:
(1) Obtained or derived from "An Inventory of Water-Related Systems and Facilities," prepared for NCTCOG by Forrest and Cotton, Inc., and Freese, Nichols and Endress, April 1968; and from the questionnaires for major wastewater treatment plants (Appendix B).
(2) Based on an estimated ratio of 3.5 persons per connection.
(3) Loadings are expressed in terms of the residential population and include industrial waste loads.

Where present values are greater than shown in Table V-5, greater unit loadings have been used. This is of particular significance in evaluating the capability of existing treatment plants to adequately treat expected future sewage flows.

INDUSTRIAL WASTEWATER

To design the sewerage system it is essential to estimate the quantity and quality of wastewater discharged from those industries that will require treatment in the future. Only a few industries in the study area discharge large amounts of process wastewater. As indicated in Chapter III, the industries in the study area are considered as light industries, i.e., they discharge small amounts of wastewater primarily associated with sanitary conveniences.

Presently most of the existing industries discharge their wastewaters into municipal sewerage systems. These discharges are included in the flow data presented in Table V-4 and are included also in the average daily flows shown on Figs. V-2, 3 and 4. They have been allowed for in the projected per capita sewage flows as previously discussed.

Existing industrial wastewater flow rates from industries outside present sewerage service areas have been determined from actual flow records and estimates. Significant industrial waste information from industries in these areas is shown on the questionnaires in Appendix C. These industries are located as shown on Figs. IV-1 and IV-2 and schematically on Fig. III-2. Flows and loads from these industries are included where applicable.

Each industrial wastewater should be carefully analyzed before being allowed to discharge into a sewerage system for subsequent treatment. Specific characteristics of individual industrial flows, present and future, may require pretreatment at the sources to prevent disruption of the municipal treatment process or for protection of the sewerage system from toxic or exceptionally strong wastes. Frequently, it is practical and economical for the large water-users to treat their own individual wastewaters, especially if reuse of water and recovery of material is possible. Such reuse is likely to increase in the future and is discussed in detail in Chapter XI.

It is anticipated that little or no development of large wastewater producing industries will occur within the study area and further that the practice of wastewater reuse will increase. However, sanitary sewage flows from the anticipated light industry are considered significant as discussed above and have been estimated based on projected employment population figures.

INFILTRATION

In designing sanitary sewers and estimating the total flow to be expected from areas already sewered, allowances must be made for the unwanted entrance of groundwater and surface waters into the sewers. The entrance of such waters places an undue and expensive burden on sewers and treatment plants by requiring the collection and treatment of these waters which become mixed with sanitary sewage and industrial wastewaters. These unwanted or extraneous waters are referred to as infiltration and

are discussed in Chapter III. The quantity varies with the type and tightness of construction, age of sewer, groundwater elevation and permeability of the surrounding soil. Infiltration also varies from season to season as the groundwater table rises and falls; it being usually lowest during prolonged dry periods in the summer and highest during the spring.

Efforts should be made to reduce infiltration and other wet weather flows wherever possible in the existing sewers to permit them to function more effectively. Since the cost of sewage treatment is determined by volume and strength of the wastewater, important savings in construction and operating costs can be realized. Reduction of infiltration can result in longer useful lives for existing and recommended facilities.

The high per capita sewage flows during wet weather periods occuring in several existing sewerage systems such as Richardson, Garland and Fort Worth bear further detailed investigation beyond the scope of this report. It is strongly recommended that a program of sewer gaging, followed by a photographic or television survey of the sewers found to be contributing the heaviest infiltration flows, be initiated immediately before proceeding with any sewage treatment plant expansion. Comparisions of the hourly sewage and water pumping rates during the early morning hours should be made where possible.

Flow records of some of the existing treatment facilities in the study area have been examined to determine present infiltration rates into existing sewers. In addition, the design allowances currently being utilized by the engineering consultants and public agencies in the area have been reviewed.

Flow data collected during March and August of 1968 for the Fort Worth and Arlington service areas were used to estimate infiltration. Other available records within the study area have also been utilized. In general, for existing sewers, 750 gal per acre per day (gpad) is considered to be representative of the maximum infiltration rate for presently developed acreage.

It is recommended that all sewers constructed in the future be provided with compression-type joints to reduce infiltration as discussed in Chapter III. In addition, it is assumed that more stringent regulations concerning house connections will be adopted in the future and that elimination of excessive leakage and unwanted connections will be accomplished. Also, it is reasonable to expect that continuing programs of sewerage system maintenance and repair will be in effect in the future. Infiltration rates for new sewers should fall within the State requirements for design, inspection and construction.

Inasmuch as sewer systems are expected to expand greatly and to become generally tighter an allowance of 750 gpad for the maximum infiltration rate based on developed acreage is considered reasonable. At a residential population density of 10 persons per acre (ppa) a maximum per capita infiltration allowance of 75 gpcd results, and this allowance has been used for preliminary flow estimates. Excessive wet weather flows caused by higher rates of infiltration may be carried by the trunk sewers up to their full capacities. Such excessive flows may require the construction of additional storm flow treatment facilities at some locations.

The selected design allowance of 750 gpad is about two times the State specification test allowance (500 gpd/mile/inch of diameter), assuming an average sewer pipe size of 10-in. The allowance is based on proper design and construction, adequate inspection and the use of modern preformed compression joints, and includes an allowance for unavoidable leakage resulting from house connections. The total length of house connections on a sewerage system often exceeds the total street sewer length.

Design infiltration allowances used for this study have been made with the consideration that annual infiltration rates throughout the study area will remain generally constant through the year 2020. Such rates combine the effects of increased infiltration into existing systems and less infiltration into new sewer systems.

SUMMARY OF PROJECTED FLOWS AND LOADS

Projected average sewage flows and loads to each node or loading point, not including flows and loads from upstream loading points, are summarized in Table V-6. These flows and loads include sewage flows from projected residential and employment population, industry and infiltration are discussed above. Projected flows and loads to each loading point in the recommended regional sewerage system are presented in Chapter X.

TABLE V-6. PROJECTED SEWAGE FLOWS AND LOADS IN THE NCTCOG STU

Node (1) No.	Location Name	1970 Avg-Flow (mgd)	1970 BOD (lb/day)	1970 SS (lb/day)	1975 Avg Flow (mgd)	1975 BOD (lb/day)	1975 SS (lb/day)	1980 Avg Flow (mgd)	1980 BOD (lb/day)	1980 SS (lb/day)	Avg Flow (mgd)
TRINITY RIVER - WATERSHED 1											
1A-211	Kerens	0.12	230	270	0.15	270	310	0.17	310	360	0.21
1A-239	NIPAK, Inc.	0.33	60	220	0.33	60	220	0.33	60	220	0.33
1B-92	Ennis North	0.27	490	580	0.34	610	720	0.45	810	950	0.61
1B-92	Sonoma	0.06	100	120	0.07	120	140	0.08	140	170	0.11
1C-91	Palmer	0.05	130	150	0.09	150	180	0.10	180	250	0.15
1C-91	Middle Red Oak Creek	0.00	0	0	0.22	390	460	0.26	470	550	0.41
1C-91E	Lower Red Oak Creek	0.00	0		0.63	1,120	1,320	0.83	1,510	1,730	1.41
1C-174	Cedar Hill	0.12	550	570	0.57	1,320	1,380	0.92	2,110	2,190	2.48
1D-145	Wilmer	0.13	680	700	0.49	1,140	1,180	0.67	1,530	1,590	1.14
1D-163	Ferris	0.12	320	380	0.21	370	430	0.24	430	500	0.33
1D-167	Lancaster	0.80	3,450	3,590	1.81	4,190	4,350	3.08	7,020	7,290	4.15
1D-167A	Upper Red Oak Creek	0.00	0	0	0.30	530	620	0.40	720	840	0.68
1D-169	De Soto	0.47	1,430	1,480	1.39	3,230	3,360	2.17	4,940	5,130	4.09
1D-170	Woodland Hills	0.00	0	0	0.10	240	250	0.15	340	360	0.32
1D-173	Duncanville	1.00	3,300	3,430	2.24	5,200	5,410	3.19	7,270	7,560	5.08
1E-147	Kleberg	0.36	1,050	1,090	0.75	1,730	1,800	1.03	2,350	2,440	1.66
1E-149	Balch Springs	0.62	2,250	2,340	1.25	2,890	3,010	1.52	3,460	3,590	2.10
1E-150	Seagoville Fed. Cor. Inst.	0.07	180	180	0.08	180	180	0.08	180	190	0.09
1F-146	Prairie Creek	5.04	13,730	14,270	7.02	16,250	16,900	8.65	19,720	20,480	11.42
1F-146	Elam Creek	1.77	3,850	4,000	2.05	4,650	4,840	2.33	5,310	5,510	2.85
1F-146	Five Mile Creek	11.45	23,580	24,520	13.91	32,200	33,480	16.03	36,550	37,960	23.44
1G-143	Hutchins	0.14	400	420	0.27	620	650	0.35	810	840	0.57
1H-64	Plano (White Rock Creek)	0.00	0	0	0.96	1,700	2,000	1.99	3,600	4,200	3.80
1H-66	Richardson Floyd Br.	1.60	3,620	3,760	1.62	3,750	3,900	1.82	4,160	4,320	2.11
1H-233	Richardson Cottonwood Creek	2.68	7,250	7,540	3.35	7,750	8,060	3.76	8,580	8,910	4.53
1H-235	Upper White Rock Creek	2.05	4,180	4,340	2.59	6,000	6,240	3.81	8,680	9,020	5.67
1H-236	Middle White Rock Creek	4.36	8,930	9,280	5.05	11,700	12,170	6.21	14,170	14,720	8.71
1H-236A	Lower White Rock Creek	18.53	37,600	39,100	19.76	45,750	47,580	22.69	51,740	53,730	27.65
1I-175	Dallas Plant Area	31.00	61,250	63,700	31.89	73,830	76,780	35.88	81,820	84,970	43.35
1I-175	Coombs Creek	23.19	46,530	48,390	24.55	56,830	59,100	28.28	64,510	66,990	34.51
1I-175	Fair Park Area	10.98	23,100	24,020	10.98	25,430	26,440	11.73	26,750	27,780	12.80
1I-175	Procter & Gamble, Inc.	0.38	4,980	2,600	0.38	4,980	2,600	0.38	4,980	2,600	0.38
	Subtotal	117.69	253,220	261,040	135.40	315,180	326,060	159.58	365,210	377,940	207.14
CEDAR CREEK - WATERSHED 2											
2A-202	Mabank	0.07	180	210	0.13	230	270	0.14	250	290	0.16
2A-203	Malakoff	0.11	290	340	0.19	340	400	0.22	400	470	0.29
2A-204	Athens (North)	0.28	690	810	0.43	760	890	0.49	880	1,020	0.65
2A-205	Athens (West)	0.40	1,150	1,350	0.71	1,260	1,480	0.81	1,470	1,710	1.08
2A-208	Trinidad	0.08	180	220	0.14	260	300	0.17	300	350	0.22
2A-208	Cedar Creek Lake Area	0.00	0	0	0.37	660	780	0.42	760	890	0.54
2B-191	Wills Point	0.23	410	480	0.23	420	490	0.25	450	530	0.28
2C-192	Terrell (Kings Creek)	1.30	2,380	2,800	1.53	2,720	3,200	1.69	3,060	3,570	2.06
2C-193	Terrell (Bachelor Creek)	0.12	260	300	0.15	270	320	0.20	360	420	0.54
2C-196	Kaufman	0.42	830	980	0.48	850	1,000	0.52	940	1,100	0.65
2C-199	Kemp	0.06	140	160	0.09	150	180	0.09	170	200	0.11
	Subtotal	3.07	6,510	7,650	4.45	7,920	9,310	5.00	9,040	10,550	6.58

(1) Node numbers shown apply to existing and potential sewage treatment plants and major loading points, and may include population from adjacent watersheds as indicated by locati

TABLE V-6. PROJECTED SEWAGE FLOWS AND LOADS IN THE NCTCOG STUDY AREA

1975 BOD (lb/day)	SS (lb/day)	Avg Flow (mgd)	1980 BOD (lb/day)	SS (lb/day)	Avg Flow (mgd)	1990 BOD (lb/day)	SS (lb/day)	Avg Flow (mgd)	2000 BOD (lb/day)	SS (lb/day)	Avg Flow (mgd)	2020 BOD (lb/day)	SS (lb/day)
270	310	0.17	310	360	0.21	350	430	0.26	400	500	0.35	500	600
60	220	0.33	60	220	0.33	60	220	0.33	100	200	0.33	100	200
610	720	0.45	810	950	0.61	1,010	1,230	0.82	1,300	1,600	1.23	1,900	2,200
120	140	0.08	140	170	0.11	170	210	0.14	200	300	0.23	400	400
150	180	0.10	180	250	0.15	240	300	0.22	400	400	0.46	700	800
390	460	0.26	470	550	0.41	670	820	0.62	1,000	1,200	1.37	2,100	2,500
1,120	1,320	0.83	1,510	1,730	1.41	2,240	4,990	2.02	3,800	4,200	4.54	6,900	8,200
1,320	1,380	0.92	2,110	2,190	2.48	5,200	5,600	4.02	8,100	8,700	7.11	13,000	14,000
1,140	1,180	0.67	1,530	1,590	1.14	2,390	2,560	1.72	3,500	3,700	3.07	5,600	6,000
370	430	0.24	430	500	0.33	540	660	0.42	700	800	0.70	1,100	1,300
4,190	4,350	3.08	7,020	7,290	4.15	8,710	9,380	5.35	10,800	11,600	8.52	15,600	16,700
530	620	0.40	720	840	0.68	1,200	1,460	1.17	1,800	2,100	2.25	3,400	4,100
3,230	3,360	2.17	4,940	5,130	4.09	8,580	9,240	6.66	13,400	14,400	12.79	23,400	25,100
240	250	0.15	340	360	0.32	680	730	0.48	1,000	1,000	0.86	1,600	1,700
5,200	5,410	3.19	7,270	7,560	5.08	10,660	11,480	8.01	16,200	17,300	14.21	26,000	27,900
1,730	1,800	1.03	2,350	2,440	1.66	3,480	3,750	2.45	4,900	5,300	4.22	7,700	8,300
2,890	3,010	1.52	3,460	3,590	2.10	4,390	4,730	2.60	5,200	5,600	4.85	8,900	9,500
180	180	0.08	180	190	0.09	180	190	0.09	200	200	0.11	200	200
16,250	16,900	8.65	19,720	20,480	11.42	23,940	25,780	15.73	31,700	34,100	22.75	41,600	44,600
4,650	4,840	2.33	5,310	5,510	2.85	5,980	6,440	3.44	6,900	7,400	4.96	9,100	9,700
32,200	33,480	16.03	36,550	37,960	23.44	49,140	52,920	29.09	58,600	63,000	39.28	71,900	77,000
620	650	0.35	810	840	0.57	1,200	1,290	0.80	1,600	1,700	1.38	2,500	2,700
1,700	2,000	1.99	3,600	4,200	3.80	6,300	7,700	4.96	8,100	9,800	6.78	10,200	12,300
3,750	3,900	1.82	4,160	4,320	2.11	4,420	4,760	2.41	4,900	5,200	2.75	5,000	5,400
7,750	8,060	3.76	8,580	8,910	4.53	9,490	10,220	4.69	9,900	10,600	5.59	10,200	11,000
6,000	6,240	3.81	8,680	9,020	5.67	11,880	12,790	7.54	15,200	16,300	9.04	16,600	17,700
11,700	12,170	6.21	14,170	14,720	8.71	18,250	19,660	11.62	23,400	25,100	16.64	30,500	32,600
45,750	47,580	22.69	51,740	53,730	27.65	57,980	62,440	32.83	66,200	71,100	41.31	75,600	81,000
73,830	76,780	35.88	81,820	84,970	43.35	90,900	97,890	51.05	103,800	111,500	62.62	114,600	122,800
56,830	59,100	28.28	64,510	66,990	34.51	72,360	77,920	39.73	80,100	86,000	46.83	85,700	91,800
25,430	26,440	11.73	26,750	27,780	12.80	26,830	28,900	13.83	27,900	29,900	15.79	28,900	31,000
4,980	2,600	0.38	4,980	2,600	0.38	4,980	2,600	0.38	5,000	2,600	0.38	5,000	2,600
15,180	326,060	159.58	365,210	377,940	207.14	434,400	469,290	255.68	516,300	533,400	343.30	626,500	671,900
230	270	0.14	250	290	0.16	270	330	0.19	300	400	0.25	400	400
340	400	0.22	400	470	0.29	490	590	0.41	700	800	0.64	1,000	1,200
760	890	0.49	880	1,020	0.65	1,070	1,310	0.90	1,500	1,800	1.39	2,100	2,500
1,260	1,480	0.81	1,470	1,710	1.08	1,780	2,180	1.61	2,600	3,200	2.32	3,500	4,200
260	300	0.17	300	350	0.22	370	450	0.31	500	600	0.48	700	900
660	780	0.42	760	890	0.54	900	1,090	0.77	1,300	1,500	1.28	1,900	2,300
420	490	0.25	450	530	0.28	470	570	0.32	500	600	0.37	600	700
2,720	3,200	1.69	3,060	3,570	2.06	3,420	4,180	2.45	4,000	4,800	2.98	4,500	5,400
270	320	0.20	360	420	0.54	900	1,100	1.28	2,100	2,500	2.98	4,500	5,400
850	1,000	0.52	940	1,100	0.65	1,080	1,320	0.78	1,300	1,500	1.07	1,600	1,900
150	180	0.09	170	200	0.11	180	220	0.13	200	200	0.16	200	300
7,920	9,310	5.00	9,040	10,550	6.58	10,930	13,340	9.15	15,000	17,900	13,92	21,000	25,200

(1) Node numbers shown apply to existing and potential sewage treatment plants and major loading points, and may include population from adjacent watersheds as indicated by location.

TABLE V-6. PROJECTED SEWAGE FLOWS AND LOADS IN THE NCTCOG STUDY A

Node[(1)] No.	Location Name	1970 Avg Flow (mgd)	1970 BOD (lb/day)	1970 SS (lb/day)	1975 Avg Flow (mgd)	1975 BOD (lb/day)	1975 SS (lb/day)	1980 Avg Flow (mgd)	1980 BOD (lb/day)	1980 SS (lb/day)	Avg Flow (mgd)
EAST FORK TRINITY - WATERSHED 3											
3A-57	North Seagoville Area	0.00	0	0	0.47	1,070	1,120	0.69	1,590	1,650	1.20
3A-58	Seagoville	0.35	1,050	1,090	0.63.	1,450	1,510	0.87	1,980	2,050	1.41
3A-61	Crandall	0.05	120	140	0.08	140	160	0.09	160	190	0.12
3B-15	Farmersville	0.20	310	370	0.22	380	450	0.23	410	480	0.26
3B-16	Rockwall	0.27	770	900	0.81	1,440	1,700	1.39	2,520	2,940	2.50
3B-20	Heath	0.00	0	0	0.10	170	200	0.39	700	820	0.54
3B-51	Forney	0.17	270	320	0.18	310	370	0.21	380	440	0.32
3C-49	Long Creek	0.00	0	0	0.24	550	570	0.37	830	880	0.65
3C-53	North Mesquite Creek	0.00	0	0	0.75	1,730	1,800	1.33	3,050	3,160	2.42
3C-54	Mesquite	5.30	13,770	14,310	6.81	15,800	16,400	8.23	18,800	19,500	11.25
3D-23	Sunnyvale (Duck Creek)	0.00	0	0	0.75	1,730	1,800	1.37	3,110	3,240	4.91
3D-45	Garland (Lower Rowlett Creek)	0.00	0	0	0.22	500	520	0.57	1,300	1,350	1.490
3D-45	Garland (Lower Duck Creek)	0	0	0	0.32	750	780	1.14	2,600	2,700	2.33
3D-67	Richardson (Duck Creek)	0.56	960	1,000	0.54	1,250	1,300	0.91	2,080	2,160	1.86
3D-67A	Garland (Upper Duck Creek)	5.45	9,650	10,000	4.65	10,750	11,200	5.59	12,730	13,200	7.68
3D-67B	Garland (Middle Duck Creek)	2.75	4,750	4,940	2.59	6,000	6,250	3.42	7,800	8,100	5.95
3D-67B	Mesquite and Dallas (Duck Creek)	0.17	330	350	0.35	800	830	0.55	1,250	1,300	0.60
3E-25	Allen	0.09	310	360	0.35	630	740	0.93	1,690	1,980	4.21
3E-26	Plano (Rowlett Creek)	0.46	770	900	1.22	2,170	2,560	3.1[illegible]	5,620	6,550	7.53
3E-31	Richardson (Rowlett Creek)	0.00	0	0	0.08	150	170	0.29	520	610	0.88
3E-33	Garland (Spring Creek)	0.33	790	830	0.94	2,180	2,260	1.65	3,770	3,920	5.07
3E-35	Sachse	0.00	0	0	0.40	920	950	0.73	1,650	1,710	1.80
3E-40	Rowlett (Rowlett Creek)	0.05	110	110	0.11	250	260	0.17	390	410	4.22
3E-40	Rowlett (Muddy Creek)	0.05	110	110	0.11	250	260	0.17	390	410	4.22
3E-40	Garland (Rowlett Creek)	2.49	3,500	3,640	2.27	5,250	5,460	3.42	7,800	8,100	5.83
3F-65	Richardson (Spring Creek)	0.84	990	1,160	0.82	1,460	1,720	1.27	2,300	2,690	2.71
3F-69	Plano (Spring Creek)	1.38	2,300	2,700	2.28	4,060	4,780	5.21	9,440	11,000	9.79
3G-34	Wylie	0.21	490	580	0.34	610	720	0.44	810	950	0.67
3H-1	Anna	0.05	80	90	0.06	100	120	0.06	110	130	0.07
3H-3	McKinney (North)	0.25	430	500	0.25	430	500	0.25	450	530	0.25
3H-24	McKinney (South)	1.40	2,820	3,320	1.85	3,300	3,880	2.22	4,020	4,680	3.65
3I-0	Van Alstyne	0.18	290	340	0.18	320	380	0.20	370	430	0.26
3I-5	Princeton	0.08	120	140	0.09	150	180	0.10	180	210	0.14
3J-7	Tom Bean	0.03	70	80	0.04	70	80	0.04	70	80	0.04
3J-8	Blue Ridge	0.02	50	70	0.03	60	70	0.04	70	80	0.04
3J-11	Trenton	0.03	140	160	0.08	140	170	0.09	160	180	0.10
3J-14	Leonard	0.09	180	210	0.11	200	240	0.12	220	260	0.15
	Subtotal	23.30	45,530	48,720	31.32	67,520	72,460	47.85	101,320	109,070	89.52
ELM FORK TRINITY - WATERSHED 4											
4A-81	Lewisville	0.62	1,960	2,300	1.45	2,980	3,540	2.31	4,630	5,560	4.09
4A-112	Grapevine Creek	0.00	0	0	0.27	500	590	1.05	1,830	2,200	4.63
4A-114	Hackberry Creek	0.00	0	0	0.32	520	620	1.59	2,420	2,900	6.95
4A-117	Carrollton	1.79	4,250	4,420	2.92	6,800	7,160	4.14	9,180	9,720	7.00
4A-120	Farmers Branch	2.73	6,500	6,760	2.92	6,800	7,160	3.68	8,160	8,640	4.63
4A-122	Dallas (California Crossing)	0.54	1,280	1,330	0.56	1,310	1,380	0.66	1,450	1,540	0.83
4A-124	Irving (Delaware Creek)	7.60	22,500	23,400	10.83	25,090	26,090	12.26	27,970	29,050	15.05
4A-163	Coppell	0.00	0	0	0.21	490	510	0.64	1,420	1,500	2.51
4B-150	Justin	0.08	240	290	0.13	270	320	0.15	300	360	0.24
4B-151	Roanoke	0.05	120	140	0.06	130	150	0.07	140	170	0.09
4B-156	Grapevine	0.47	1,120	1,170	1.52	3,550	3,740	2.59	5,750	6,090	3.80
4B-159	Future Development	0.00	0	0	0.01	30	30	0.01	30	30	0.03
4B-161	Future Development	0.00	0	0	0.01	30	30	0.01	30	30	0.03
4C-50	Muenster	0.14	260	300	0.14	290	340	0.17	340	410	0.22
4C-51	Myra	0.01	20	20	0.01	20	30	0.01	20	30	0.02
4C-54	Lindsay	0.02	60	70	0.03	70	80	0.04	70	90	0.04
4C-55	Gainesville	1.50	3,060	3,600	1.65	3,390	4,020	1.86	3,720	4,470	2.32
4C-58	Valley View	0.08	160	190	0.09	180	210	0.10	200	240	0.14
4C-70A	Lake Dallas	0.07	160	180	0.09	180	210	0.11	220	270	0.15
4C-71	Denton	3.70	7,820	9,200	4.92	10,150	12,020	6.23	12,480	14,970	8.17
4C-74	Camp Copass	0.01	30	40	0.02	40	40	0.02	40	50	0.03
4C-76	Shady Shores	0.01	20	30	0.01	30	30	0.02	30	40	0.02
4C-206	Prosper	0.03	60	70	0.04	80	100	0.04	90	110	0.05
4C-209	Frisco	0.11	390	460	0.20	410	490	0.22	430	520	0.25
4D-100	Krum	0.02	90	100	0.05	100	120	0.06	120	150	0.09
4D-104	Argyle	0.02	50	60	0.03	60	70	0.02	60	80	0.05
4E-2	Rosston	0.01	20	30	0.01	30	30	0.01	30	30	0.02
4E-3	Leo	0.01	20	20	0.01	20	20	0.01	20	20	0.01
4E-8	Bolivar	0.01	20	30	0.01	30	30	0.02	30	40	0.02
4E-10	Sanger	0.14	350	410	0.19	400	470	0.24	480	580	0.32
4F-60	Pilot Point	0.15	410	480	0.22	460	540	0.27	540	650	0.34
4F-64	Aubrey	0.06	170	200	0.10	200	240	0.13	250	300	0.18
4F-200	Gunter	0.05	90	100	0.06	130	150	0.07	140	170	0.09
4F-204	Celina	0.10	270	320	0.16	330	400	0.17	350	420	0.20
4G-213	Collinsville	0.06	110	120	0.06	120	140	0.06	130	150	0.08
4G-214	Tioga	0.04	80	100	0.04	90	110	0.05	100	120	0.06
	Subtotal	20.23	51,690	55,940	29.35	65,310	71,210	39.09	83,200	91,690	62.75

V-6. PROJECTED SEWAGE FLOWS AND LOADS IN THE NCTCOG STUDY AREA (Continued)

		1980			1990			2000			2020		
y)	SS (lb/day)	Avg Flow (mgd)	BOD (lb/day)	SS (lb/day)	Avg Flow (mgd)	BOD (lb/day)	SS (lb/day)	Avg Flow (mgd)	BOD (lb/day)	SS (lb/day)	Avg Flow (mgd)	BOD (lb/day)	SS (lb/day)
70	1,120	0.69	1,590	1,650	1.20	2,520	2,710	2.00	4,000	4,300	3.33	6,100	6,600
50	1,510	0.87	1,980	2,050	1.41	2,960	3,190	2.10	4,200	4,600	4.21	7,700	8,300
40	160	0.09	160	190	0.12	200	240	0.16	300	300	0.26	400	500
80	450	0.23	410	480	0.26	430	530	0.29	500	600	0.36	500	600
40	1,700	1.39	2,520	2,940	2.50	4,140	5,060	3.73	6,100	7,400	4.56	6,900	8,300
70	200	0.39	700	820	0.54	900	1,100	0.82	1,300	1,600	1.33	2,000	2,400
10	370	0.21	380	440	0.32	530	650	0.45	700	900	0.73	1,100	1,300
50	570	0.37	830	880	0.65	1,350	1,460	1.01	2,100	2,200	1.90	3,500	3,700
30	1,800	1.33	3,050	3,160	2.42	5,090	5,480	3.58	7,200	7,800	6.41	11,700	12,600
00	16,400	8.23	18,800	19,500	11.25	23,600	25,400	15.80	31,800	34,100	19.28	35,300	37,800
30	1,800	1.37	3,110	3,240	4.91	10,300	11,090	5.70	11,500	12,300	6.50	11,900	12,800
00	520	0.57	1,300	1,350	1.490	3,120	3,360	1.61	3,200	3,500	1.84	3,400	3,600
50	780	1.14	2,600	2,700	2.33	4,890	5,260	2.52	5,100	5,500	2.88	5,300	5,600
50	1,300	0.91	2,080	2,160	1.86	3,900	4,200	2.68	5,400	5,800	3.93	7,200	7,700
50	11,200	5.59	12,730	13,200	7.68	16,100	17,340	8.29	16,700	18,000	9.46	17,300	18,600
00	6,250	3.42	7,800	8,100	5.95	12,490	13,440	6.43	13,000	13,900	7.35	13,400	14,400
00	830	0.55	1,250	1,300	0.60	1,250	1,340	0.64	1,300	1,400	0.74	1,300	1,400
30	740	0.93	1,690	1,980	4.21	6,990	8,530	8.38	13,700	16,500	11.77	17,800	21,300
70	2,560	3.10	5,620	6,550	7.53	12,500	15,300	9.64	15,700	19,000	11.90	18,000	21,600
50	170	0.29	520	610	0.88	1,460	1,780	2.00	3,300	4,000	2.66	4,000	4,800
80	2,260	1.65	3,770	3,920	5.07	10,640	11,450	5.94	12,000	12,900	6.78	12,400	13,300
20	950	0.73	1,650	1,710	1.80	3,770	4,060	2.43	4,900	5,200	2.80	5,100	5,500
50	260	0.17	390	410	4.22	880	950	1.01	2,000	2,200	1.61	2,900	3,200
50	260	0.17	390	410	4.22	880	950	1.01	2,000	2,200	1.61	2,900	3,200
50	5,460	3.42	7,800	8,100	5.83	12,220	13,170	6.70	13,500	14,500	7.96	14,600	15,600
60	1,720	1.27	2,300	2,690	2.71	4,480	5,480	3.15	5,100	6,200	3.58	5,400	6,500
60	4,780	5.21	9,440	11,000	9.79	16,210	19,800	10.66	17,400	21,100	12.12	18,300	22,000
10	720	0.44	810	950	0.67	1,120	1,360	1.01	1,600	2,000	1.79	2,700	3,200
100	120	0.06	110	130	0.07	110	130	0.07	100	100	0.08	100	100
30	500	0.25	450	530	0.25	450	550	0.25	500	600	0.25	500	600
300	3,880	2.22	4,020	4,680	3.65	6,060	7,400	6.56	10,700	13,000	9.28	14,000	16,800
320	380	0.20	370	430	0.26	430	530	0.33	500	700	0.50	800	900
150	180	0.10	180	210	0.14	240	290	0.20	300	400	0.33	500	600
70	80	0.04	70	80	0.04	70	90	0.05	100	100	0.05	100	100
60	70	0.04	70	80	0.04	70	90	0.05	100	100	0.06	100	100
140	170	0.09	160	180	0.10	170	210	0.12	200	200	0.14	200	300
200	240	0.12	220	260	0.15	240	300	0.17	300	300	0.20	300	400
520	72,460	47.85	101,320	109,070	89.52	172,760	194,270	116.88	218,400	245,500	150.54	255,700	286,300
980	3,540	2.31	4,630	5,560	4.09	7,870	9,610	5.27	10,100	12,200	9.01	15,600	18,800
500	590	1.05	1,830	2,200	4.63	7,660	9,300	8.05	13,000	15,800	10.50	15,800	18,900
520	620	1.59	2,420	2,900	6.95	10,010	12,230	11.41	16,100	19,400	15.45	20,200	24,200
800	7,160	4.14	9,180	9,720	7.00	14,560	15,680	8.24	16,300	17,500	10.71	19,600	21,000
800	7,160	3.68	8,160	8,640	4.63	9,620	10,360	5.81	11,500	12,300	8.92	15,400	16,500
310	1,380	0.66	1,450	1,540	0.83	1,720	1,850	1.04	2,100	2,200	1.53	2,800	3,000
090	26,090	12.26	27,970	29,050	15.05	31,550	33,980	17.43	35,100	37,700	22.92	41,900	44,900
490	510	0.64	1,420	1,500	2.51	5,230	5,630	4.05	8,000	8,600	5.23	9,600	10,300
270	320	0.15	300	360	0.24	470	570	0.43	800	1,000	0.66	1,200	1,400
130	150	0.07	140	170	0.09	170	200	0.10	200	200	0.16	300	300
550	3,740	2.59	5,750	6,090	3.80	7,900	8,510	4.85	9,000	9,700	6.04	11,000	11,800
30	30	0.01	30	30	0.03	50	60	0.04	100	100	0.07	100	100
30	30	0.01	30	30	0.03	50	60	0.04	100	100	0.07	100	100
290	340	0.17	340	410	0.22	410	510	0.29	500	700	0.53	900	1,100
20	30	0.01	20	30	0.02	40	40	0.03	100	100	0.04	100	100
70	80	0.04	70	90	0.04	80	100	0.05	100	100	0.07	100	100
390	4,020	1.86	3,720	4,470	2.32	4,470	5,470	2.65	5,100	6,100	3.71	6,400	7,700
180	210	0.10	200	240	0.14	260	320	0.18	400	400	0.30	500	600
180	210	0.11	220	270	0.15	290	350	0.22	400	500	0.36	600	700
150	12,020	6.23	12,480	14,970	8.17	15,730	19,230	10.88	20,800	25,100	15.90	27,600	33,100
40	40	0.02	40	50	0.03	60	70	0.05	100	100	0.08	100	200
30	30	0.02	30	40	0.02	40	50	0.04	100	100	0.06	100	100
80	100	0.04	90	110	0.05	100	120	0.06	100	100	0.08	100	200
410	490	0.22	430	520	0.25	480	590	0.32	600	700	0.35	600	700
100	120	0.06	120	150	0.09	180	220	0.12	200	300	0.20	300	400
60	70	0.02	60	80	0.05	90	110	0.06	100	100	0.11	200	200
30	30	0.01	30	30	0.02	40	40	0.03	100	100	0.04	100	100
20	20	0.01	20	20	0.01	20	30	0.01	100	100	0.02	100	100
30	30	0.02	30	40	0.02	40	50	0.03	100	100	0.07	100	100
400	470	0.24	480	580	0.32	620	760	0.43	800	1,000	0.64	1,100	1,300
460	540	0.27	540	650	0.34	660	810	0.44	800	1,000	0.69	1,200	1,400
200	240	0.13	250	300	0.18	350	430	0.26	500	600	0.40	700	800
130	150	0.07	140	170	0.09	170	210	0.11	300	300	0.18	300	400
330	400	0.17	350	420	0.20	390	480	0.23	400	500	0.31	600	700
120	140	0.06	130	150	0.08	150	190	0.10	200	200	0.16	300	300
90	110	0.05	100	120	0.06	120	140	0.08	100	200	0.12	200	300
310	71,210	39.09	83,200	91,690	62.75	121,650	138,360	83.43	154,400	175,300	115.69	195,900	222,000

TABLE V-6. PROJECTED SEWAGE FLOWS AND LOADS IN THE NCTCOG ST

Node (1) No.	Location Name	1970 Avg Flow (mgd)	1970 BOD (lb/day)	1970 SS (lb/day)	1975 Avg Flow (mgd)	1975 BOD (lb/day)	1975 SS (lb/day)	1980 Avg Flow (mgd)	1980 BOD (lb/day)	1980 SS (lb/day)	Avg F (mgd
BIG BEAR CREEK and LITTLE BEAR CREEK - WATERSHEDS 5A and 5B											
5A-19	Regional Airport	0.00	0	0	2.60	6,070	6,380	3.80	8,430	8,920	5.00
5A-20	Keller	0.12	290	320	0.31	730	760	0.44	980	1,040	0.75
5A-21	Southlake	0.09	210	210	0.13	310	320	0.19	430	450	0.54
5A-22	Southlake	0.09	210	210	0.13	310	320	0.19	430	450	0.54
5A-23	Colleyville	0.17	410	430	0.57	1,340	1,410	1.04	2,300	2,430	1.96
5A-24	Grapevine	0.64	880	910	1.78	2,750	2,890	2.01	4,450	4,710	2.95
5A-30	Irving	0.06	150	160	0.41	950	990	0.72	1,610	1,700	1.75
5A-60	Greenview	0.04	100	100	0.04	100	110	0.05	110	120	0.06
5B-25	North Richland Hills	0.16	380	390	0.22	500	530	0.29	630	080	0.44
5B-26	Hurst	0.37	880	910	0.43	1,010	1,060	0.52	1,150	1,220	0.63
5B-27	Bedford	0.05	130	130	0.11	250	270	0.17	380	410	0.31
5B-28	Colleyville	0.00	0	0	0.00	0	0	0.00	0	0	0.00
5B-29	Euless	0.46	1,090	1,130	0.97	1,100	1,150	1.50	3,320	3,510	1.81
	Subtotal	2.25	4,730	4,900	7.70	15,420	16,190	10.92	24,220	25,640	16.74
WATERSHEDS 5C, 5D, 5E, 5F											
5C-1	Venus	0.04	60	70	0.04	60	80	0.04	70	80	0.05
5C-65	Grand Prairie	3.21	7,800	8,110	3.98	9,220	9,590	5.16	11,670	12,210	7.49
5C-208	East Mountain Creek	0.03	80	80	0.28	650	680	0.35	800	830	0.50
5C-211	East Mountain Creek	0.02	50	50	0.41	940	980	0.73	1,670	1,740	1.46
5C-350	Kirby Creek	3.20	7,720	8,030	4.03	9,320	9,690	4.89	11,090	11,510	6.70
5C-450	Future Development	0.01	20	20	0.05	110	120	0.51	1,170	1,210	1.11
5C-451	Future Development	0.02	50	60	0.15	350	370	0.32	740	760	0.70
5C-452	Future Development	0.02	60	60	0.16	380	400	1.74	3,970	4,130	3.79
5C-453	Future Development	0.01	20	20	0.07	160	170	0.73	1,660	1,730	1.59
5C-500	Midlothian	0.13	410	420	0.18	490	500	0.23	610	630	0.37
5D-214	Mansfield	0.24	590	620	0.27	630	660	0.54	1,240	1,280	1.24
5D-448	Future Development	0.01	20	20	0.06	140	140	0.63	1,440	1,500	1.38
5D-449	Future Development	0.01	20	20	0.04	100	110	0.47	1,080	1,120	1.03
5E-195	Arlington	4.94	11,980	12,450	6.14	14,210	14,770	8.81	19,910	20,860	14.04
5F-184	Euless (West)	0.90	2,180	2,270	2.47	4,470	4,650	3.88	8,850	9,190	7.05
5F-186	Arlington	0.49	1,090	1,130	0.56	1,290	1,340	0.80	1,830	1,900	1.28
5F-188	Euless (East)	0.22	540	570	0.46	1,060	1,100	0.97	2,210	2,300	2.26
5F-190	Arlington	0.45	1,090	1,130	0.56	1,290	1,340	0.80	1,830	1,900	1.28
	Subtotal	13.95	33,780	35,130	19.91	44,870	46,680	31.60	71,840	74,880	53.32
WEST FORK TRINITY - WATERSHED 5											
5G-123	Fort Worth	5.14	12,250	12,250	6.81	15,880	16,700	9.17	20,340	21,530	13.2
5G-130	Burleson	0.27	570	660	0.31	640	760	0.35	700	850	0.4
5G-132	Crowley	0.11	270	280	0.21	500	530	0.35	770	810	0.7
5G-134	Fort Worth	3.09	7,350	7,640	4.08	9,530	10,020	5.51	12,210	12,930	7.9
5G-136	Everman	0.24	580	600	0.42	980	1,030	0.56	1,240	1,310	0.6
5G-137	Kennedale	0.18	440	450	0.63	1,470	1,590	1.04	2,300	2,430	1.7
5G-138	Forest Hill	0.43	1,030	1,070	0.73	1,700	1,790	1.09	2,420	2,570	2.1
5H-141	Banfield Mobile Home Park	0.01	30	30	0.03	80	80	0.07	150	160	0.2
5H-143	Royal Coach Mobile Home Park	0.10	240	250	0.11	260	280	0.20	430	460	0.5
5H-145	L & M Mobile Home Park	0.01	20	20	0.01	30	30	0.02	40	40	0.0
5H-146	Dalworthington Gardens	0.12	280	290	0.21	500	520	0.32	710	760	0.6
5H-149	Treetop Mobile Home Park	0.03	80	80	0.04	100	110	0.08	180	190	0.2
5H-150	Treetop Mobile Home Park South	0.10	230	240	0.10	240	250	0.14	310	320	0.3
5H-153	Tumbleweed Mobile Home Park	0.06	150	160	0.11	400	430	0.21	460	490	0.5
5H-156	Wilson	0.01	10	10	0.03	80	80	0.08	180	190	0.2
5H-157	Parsons	0.01	10	10	0.03	80	80	0.16	260	270	0.4
5H-158	Pantego	0.12	280	300	0.26	610	640	0.32	710	760	0.6
5H-199	Arlington	0.90	2,180	2,260	1.12	2,580	2,690	1.60	3,560	3,790	2.5
5H-200	Arlington	0.90	2,180	2,260	1.12	2,580	2,690	1.60	3,560	3,790	2.5
5I-117	North Richland Hills	1.31	3,120	3,250	1.87	4,360	4,580	2.88	6,380	6,750	3.9
5I-117	Watauga	0.10	240	250	0.37	860	910	0.59	1,310	1,390	0.9
5I-117	Hurst	0.44	1,050	1,090	1.21	2,810	2,960	1.87	4,140	4,390	3.0
5I-118	Hurst	1.29	3,070	3,200	3.52	8,210	8,640	5.46	12,100	12,810	8.8
5I-168	Richland Hills	0.46	1,090	1,130	0.55	1,280	1,350	0.68	1,500	1,590	0.9
5J-112	Richland Hills	0.46	1,090	1,130	0.55	1,280	1,350	0.68	1,500	1,590	0.9
5J-113	Haltom City	2.69	6,410	6,670	4.50	10,500	11,040	6.10	13,120	14,310	8.8
5K-166	Saginaw	0.17	410	430	0.31	730	760	0.69	1,530	1,620	1.3
5K-167	Bluemound	0.13	320	330	0.26	610	640	0.33	730	770	0.4
5K-183	American Manufacturing Company	0.22	250	4,600	0.22	250	4,600	0.28	300	5,800	0.2
5K-184	Fort Worth Refining Company	0.21	180	70	0.21	180	70	0.26	200	90	0.2
5M-92	Fort Worth	5.14	12,250	12,740	6.81	15,880	16,700	9.17	20,340	21,530	13.2
5M-92	Fort Worth	3.09	7,350	7,640	4.08	9,530	10,020	5.51	12,210	12,930	7.9
5M-123	Fort Worth	9.26	22,050	22,930	12.25	28,590	30,070	16.52	36,020	38,770	23.8
5M-181	Texas and Pacific, Missouri and Pacific Railroad Company	0.29	490	310	0.29	490	310	0.36	600	400	0.3

TABLE V-6. PROJECTED SEWAGE FLOWS AND LOADS IN THE NCTCOG STUDY AREA (Continued)

975			1980			1990			2000			2020	
BOD (lb/day)	SS (lb/day)	Avg Flow (mgd)	BOD (lb/day)	SS (lb/day)	Avg Flow (mgd)	BOD (lb/day)	SS (lb/day)	Avg Flow (mgd)	BOD (lb/day)	SS (lb/day)	Avg Flow (mgd)	BOD (lb/day)	SS (lb/day)
,070	6,380	3.80	8,430	8,920	5.00	10,040	11,200	6.00	11,900	12,800	7.50	13,700	14,700
730	760	0.44	980	1,040	0.75	1,550	1,670	1.03	2,000	2,200	1.22	2,200	2,400
310	320	0.19	430	450	0.54	1,110	1,200	0.85	1,700	1,800	1.53	2,800	3,000
310	320	0.19	430	450	0.54	1,110	1,200	0.85	1,700	1,800	1.53	2,800	3,000
,340	1,410	1.04	2,300	2,430	1.96	4,070	4,390	2.70	5,300	5,700	4.59	8,400	9,000
,750	2,890	2.01	4,450	4,710	2.95	6,140	6,610	3.25	7,000	7,500	4.67	8,500	9,200
950	990	0.72	1,610	1,700	1.75	3,680	3,960	2.85	5,700	6,100	4.77	8,700	9,400
100	110	0.05	110	120	0.06	120	130	0.06	100	100	0.08	100	200
500	530	0.29	630	080	0.44	910	980	0.61	1,200	1,300	0.92	1,700	1,800
,010	1,060	0.52	1,150	1,220	0.63	1,300	1,400	0.74	1,500	1,600	0.92	1,700	1,800
250	270	0.17	380	410	0.31	650	700	0.47	900	1,000	0.92	1,700	1,800
0	0	0.00	0	0	0.00	0	0	0.27	800	900	0.96	1,800	2,000
,100	1,150	1.50	3,320	3,510	1.81	3,770	4,060	2.16	4,300	4,600	2.75	5,000	5,400
,420	16,190	10.92	24,220	25,640	16.74	34,450	37,500	21.84	44,100	47,400	32.36	59,100	63,700
60	80	0.04	70	80	0.05	80	100	0.06	100	100	0.10	200	200
,220	9,590	5.16	11,670	12,210	7.49	15,710	16,920	10.03	20,300	21,700	14.97	27,400	29,300
650	680	0.35	800	830	0.50	1,040	1,120	0.70	1,400	1,500	1.21	2,200	2,400
940	980	0.73	1,670	1,740	1.46	3,060	3,290	2.59	5,200	5,600	4.13	7,600	8,100
,320	9,690	4.89	11,090	11,510	6.70	14,030	15,110	8.55	17,200	18,500	12.85	23,500	25,200
110	120	0.51	1,170	1,210	1.11	2,330	2,510	1.50	3,000	3,300	2.74	5,000	5,400
350	370	0.32	740	760	0.70	1,470	1,580	4.74	9,500	10,200	8.65	15,800	16,900
380	400	1.74	3,970	4,130	3.79	7,950	8,560	5.12	10.300	11,100	9.35	17,100	18,300
160	170	0.73	1,660	1,730	1.59	3,330	3,580	2.14	4,300	4,600	3.92	7,200	7,700
490	500	0.23	610	630	0.37	900	960	0.61	1,400	1,500	1.66	3,500	3,800
630	660	0.54	1,240	1,280	1.24	2,600	2,800	2.75	5,500	5,900	7.65	14,000	15,000
140	140	0.63	1,440	1,500	1.38	2,890	3,110	1.86	3,700	4,000	3.40	6,200	6,700
100	110	0.47	1,080	1,120	1.03	2,150	2,320	1.39	2,800	3,000	2.54	4,600	5,000
210	14,770	8.81	19,910	20,860	14.04	29,430	31,690	20.27	40,800	43,900	31.56	57,800	61,900
470	4,650	3.88	8,850	9,190	7.05	14,790	15,930	11.29	22,700	24,400	24.46	44,800	48,000
290	1,340	0.80	1,830	1,900	1.28	2,680	2,880	1.84	3,700	4,000	2.87	5,200	5,600
060	1,100	0.97	2,210	2,300	2.26	4,730	5,0[illegible]0	4.29	8,600	9,300	11.63	21,300	22,800
290	1,340	0.80	1,830	1,900	1.28	2,680	2,880	1.84	3,700	4,000	2.86	5,200	5,600
870	46,680	31.60	71,840	74,880	53.32	111,850	120,430	81.57	164,200	176,600	146.55	268,600	287,900
880	16,700	9.17	20,340	21,530	13.23	27,510	29,620	15.90	31,400	33,800	21.52	39,400	42,200
640	760	0.35	700	850	0.44	850	1,040	0.78	1,300	1,500	1.30	3,000	2,300
500	530	0.35	770	810	0.75	1,550	1,670	1.03	2,000	2,200	1.38	2,500	2,700
530	10,020	5.51	12,210	12,930	7.94	16,510	17,770	9.54	18,800	20,300	12.91	23,600	25,300
980	1,030	0.56	1,240	1,310	0.69	1,430	1,540	0.74	1,500	1,600	0.84	1,500	1,600
470	1,590	1.04	2,300	2,430	1.74	3,610	3,890	2.84	5,600	6,000	6.12	11,200	12,000
700	1,790	1.09	2,420	2,570	2.12	4,410	4,800	3.04	6,000	6,500	4.59	8,400	9,000
80	80	0.07	150	160	0.20	420	450	0.35	700	700	0.61	1,100	1,200
260	280	0.20	430	460	0.50	1,040	1,120	1.15	2,300	2,400	1.99	3,600	3,900
30	30	0.02	40	40	0.09	180	200	0.18	400	400	0.32	600	600
500	520	0.32	710	760	0.61	1,260	1,360	0.69	1,400	1,500	0.86	1,600	1,700
100	110	0.08	180	190	0.28	570	620	0.81	1,600	1,700	1.59	2,900	3,100
240	250	0.14	310	320	0.39	700	760	0.85	1,700	1,800	1.65	3,000	3,200
400	430	0.21	460	490	0.55	1,140	1,230	1.08	2,100	2,300	1.79	3,300	3,500
80	80	0.08	180	190	0.27	560	600	0.69	1,200	1,300	1.26	2,300	2,500
80	80	0.16	260	270	0.43	880	950	1.08	2,100	2,300	1.90	3,500	3,700
610	640	0.32	710	760	0.61	1,260	1,360	0.72	1,400	1,500	1.00	1,800	2,000
580	2,690	1.60	3,560	3,790	2.55	5,350	5,760	3.69	7,400	8,000	5.74	10,500	11,300
580	2,690	1.60	3,560	3,790	2.55	5,350	5,760	3.69	7,400	8,000	5.74	10,500	11,300
360	4,580	2.88	6,380	6,750	3.94	8,190	8,820	4.73	9,300	10,000	9.95	18,200	19,500
860	910	0.59	1,310	1,390	0.99	2,060	2,220	1.24	2,500	2,600	1.55	2,800	3,000
810	2,960	1.87	4,140	4,390	3.03	6,300	6,780	4.22	8,300	9,000	6.50	11,900	12,800
210	8,640	5.46	12,100	12,810	8.84	18,400	19,810	12.32	24,400	26,200	18.99	34,700	37,200
280	1,350	0.68	1,500	1,590	0.91	1,890	2,040	0.98	1,900	2,000	1.12	1,900	2,000
280	1,350	0.68	1,500	1,590	0.91	1,890	2,040	0.91	1,900	2,000	0.91	1,900	2,000
500	11,040	6.10	13,120	14,310	8.86	18,440	19,890	12.15	24,000	25,800	21.42	39,200	42,000
730	760	0.69	1,530	1,620	1.35	2,810	3,030	1.46	2,800	3,000	1.66	2,800	3,000
610	640	0.33	730	770	0.44	920	1,000	0.48	900	1,000	0.54	900	1,000
250	4,600	0.28	300	5,800	0.28	300	5,800	0.28	300	5,800	0.33	400	6,900
180	70	0.26	200	90	0.26	200	90	0.26	200	100	0.31	300	100
880	16,700	9.17	20,340	21,530	13.23	27,510	29,620	15.90	31,400	33,800	21.52	39,400	42,200
530	10,020	5.51	12,210	12,930	7.94	16,510	17,770	9.54	18,900	20,300	12.91	23,600	25,300
590	30,070	16.52	36,020	38,770	23.81	49,520	53,320	28.62	56,600	60,800	38.73	70,900	75,900
490	310	0.36	600	400	0.36	600	400	0.36	600	400	0.43	700	500

TABLE V-6. PROJECTED SEWAGE FLOWS AND LOADS IN THE NCTCOG S

Node(1) No.	Location Name	1970 Avg Flow (mgd)	1970 BOD (lb/day)	1970 SS (lb/day)	1975 Avg Flow (mgd)	1975 BOD (lb/day)	1975 SS (lb/day)	1980 Avg Flow (mgd)	1980 BOD (lb/day)	1980 SS (lb/day)	Avg (
WEST FORK TRINITY - WATERSHED 5, continued											
5M-182	American Cyanamid Company	1.00	420	8,340	1.00	420	8,340	1.25	500	10,400	1
5N-94	Edgecliff	0.07	160	160	0.57	1,380	1,450	0.77	1,750	1,850	0
5N-97	Fort Worth	2.06	4,900	5,100	2.72	6,350	6,680	3.67	8,140	8,620	5
5N-98	Fort Worth	2.06	4,900	5,100	2.72	6,350	6,680	3.67	8,140	8,620	5
5N-99	Fort Worth	3.09	7,350	7,640	4.08	9,530	10,020	5.51	12,210	12,930	7
5N-100	Fort Worth	4.12	9,800	10,190	5.45	12,660	13,320	7.34	16,280	17,230	10
5N-100	Fort Worth	4.12	9,800	10,190	5.45	12,660	13,320	7.34	16,280	17,230	10
5Q-71	Benbrook	0.67	1,600	1,660	1.25	2,930	3,080	1.73	3,830	4,050	3
5Q-72	St. Francis Village	0.11	260	270	0.13	300	320	0.16	340	360	0
5Q-73	Weatherford	1.41	3,000	3,600	1.79	3,680	4,360	2.01	4,030	4,380	2
5Q-75	Lake Weatherford	0.12	210	240	0.13	260	310	0.13	270	320	0
5Q-76	Aledo	0.04	70	90	0.04	80	100	0.04	80	100	0
5S-18	Chico	0.06	130	160	0.07	140	170	0.08	150	180	0
5S-19	Bridgeport	0.38	800	940	0.47	970	1,160	0.54	1,040	1,300	0
5S-23	Runaway Bay	0.01	30	30	0.12	250	250	0.15	300	350	0
5S-25	Wizard Wells	0.01	10	10	0.01	10	20	0.01	20	20	0
5S-35	Jermyn	0.10	280	290	0.11	290	300	0.12	290	300	0
5S-38	Jacksboro	0.37	760	840	0.41	860	1,010	0.44	890	1,060	0
5S-39	Decatur	0.03	790	920	0.46	930	1,090	0.51	1,030	1,200	0
5S-43	Paradise	0.03	70	80	0.04	90	100	0.05	110	120	0
5S-46	Boyd	0.06	120	140	0.07	140	170	0.08	150	180	0
5S-46	Aurora	0.01	20	20	0.01	20	30	0.01	20	30	0
5S-46	Rhome	0.04	80	90	0.04	90	110	0.05	100	120	0
5S-47	Newark	0.04	80	100	0.06	120	140	0.07	140	170	0
5S-51	Reno	0.01	20	20	0.01	20	20	0.01	20	20	0
5S-51A	La Junta	0.05	130	130	0.06	160	170	0.06	190	200	0
5S-51A	Highland Addition	0.04	100	100	0.05	120	130	0.06	140	150	0
5S-52	Springtown	0.10	200	220	0.12	250	300	0.14	280	340	0
5S-59	Lakeside	0.10	240	250	0.31	730	760	0.43	960	1,010	0
5S-60	Lake Worth	0.610	1,450	1,510	0.68	1,590	1,670	0.92	2,040	2,160	1
5S-63	Sansom Park	0.45	1,070	1,110	0.68	1,590	1,670	0.83	1,850	1,960	1
5S-69	River Oaks	0.86	2,060	2,140	0.940	2,200	2,300	1.00	2,200	2,310	1
5S-69	Westover Hills	0.07	100	100	0.11	250	260	0.11	250	260	0
5S-70	Westworth Village	0.30	730	750	0.37	860	900	0.46	1,020	1,080	0
5S-70	White Settlement	1.22	2,900	3,020	1.58	3,670	3,860	1.96	4,340	4,590	2
5S-175	Azle	0.35	820	860	0.68	1,590	1,670	1.04	2,300	2,430	1
5T-1	Bowie	0.62	1,280	1,600	0.77	1,580	1,870	0.90	1,800	2,160	1
5T-4	Lake Amon G. Carter	0.05	90	100	0.06	130	150	0.07	150	180	0
5T-6	Sunset	0.02	30	40	0.02	40	50	0.02	50	50	0
5T-9	Park Springs	0.01	10	10	0.01	10	20	0.01	10	20	0
5T-11	Alvord	0.06	130	150	0.07	150	180	0.08	150	180	0
	Subtotal	62.02	144,550	163,430	87.08	199,250	222,810	118.06	256,350	288,610	172
CHAMBERS CREEK, WAXAHACHIE CREEK - WATERSHED 10											
10A-80	Alvarado	0.12	280	330	0.18	320	380	0.20	350	410	0
10A-81	Maypearl	0.03	60	70	0.04	60	80	0.04	70	80	0
10A-83	Grandview	0.09	180	210	0.11	200	230	0.12	200	240	0
10A-84	Italy	0.11	240	280	0.16	280	330	0.16	300	350	0
10A-86	Milford	0.05	70	80	0.05	80	100	0.05	90	100	0
10A-97	Corsicana*	2.09	3,890	4,580	2.33	4,150	4,880	2.60	4,700	5,480	3
10A-99	Forreston	0.02	40	50	0.03	60	70	0.04	60	70	0
10B-89	Waxahachie	1.20	2,890	3,400	2.01	3,570	4,200	2.49	4,500	5,250	3
10B-544	Bardwell	0.02	34	40	0.02	39	46	0.02	45	53	0
	Subtotal*	1.64	3,794	4,460	2.60	4,609	5,436	3.12	5,615	6,553	4
11A-94	Ennis	0.86	1,500	1,760	1.09	1,940	2,280	1.34	2,430	2,840	1
	Subtotal	0.86	1,500	1,760	1.09	1,940	2,280	1.34	2,430	2,840	1
12A-18	Royse City	0.14	290	340	0.23	410	500	0.40	720	840	0
12A-501	Josephine	0.03	51	60	0.04	68	80	0.05	90	105	0
	Subtotal	0.17	341	400	0.27	478	580	0.45	810	945	0
	Study Area Total*	245.18	545,645	583,430	319.17	722,497	773,016	417.01	920,035	988,728	615

*Corsicana is outside the study area, and its population is not included in watershed subtotals or study area totals

TABLE V-6. PROJECTED SEWAGE FLOWS AND LOADS IN THE NCTCOG STUDY AREA (Continued)

1975 BOD (lb/day)	1975 SS (lb/day)	1980 Avg Flow (mgd)	1980 BOD (lb/day)	1980 SS (lb/day)	1990 Avg Flow (mgd)	1990 BOD (lb/day)	1990 SS (lb/day)	2000 Avg Flow (mgd)	2000 BOD (lb/day)	2000 SS (lb/day)	2020 Avg Flow (mgd)	2020 BOD (lb/day)	2020 SS (lb/day)
420	8,340	1.25	500	10,400	1.25	500	10,400	1.25	500	10,400	1.50	600	12,500
1,380	1,450	0.77	1,750	1,850	0.91	1,930	2,080	0.98	2,000	2,100	1.11	2,100	2,200
6,350	6,680	3.67	8,140	8,620	5.29	11,000	11,850	6.36	12,600	13,500	8.61	15,800	16,800
6,350	6,680	3.67	8,140	8,620	5.29	11,000	11,850	6.36	12,600	13,500	8.61	15,800	16,800
9,530	10,020	5.51	12,210	12,930	7.94	16,510	17,770	9.54	18,900	20,300	12.91	23,600	25,300
2,660	13,320	7.34	16,280	17,230	10.83	22,010	23,700	12.72	25,200	27,000	17.21	31,500	33,800
2,660	13,320	7.34	16,280	17,230	10.83	22,010	23,700	12.72	25,200	27,000	17.21	31,500	33,800
2,930	3,080	1.73	3,830	4,050	3.17	6,590	7,100	3.44	6,800	7,300	5.36	9,800	10,400
300	320	0.16	340	360	0.19	390	420	0.23	500	500	0.31	600	600
3,680	4,360	2.01	4,030	4,380	2.37	4,560	5,570	3.00	5,700	7,000	4.90	8,500	10,200
260	310	0.13	270	320	0.15	280	340	0.16	300	400	0.20	300	400
80	100	0.04	80	100	0.05	90	100	0.05	100	100	0.06	100	100
140	170	0.08	150	180	0.09	170	200	0.10	200	200	0.150	300	300
970	1,160	0.54	1,040	1,300	0.74	1,430	1,750	0.92	1,800	2,100	1.46	2,500	3,000
250	250	0.15	300	350	0.22	410	510	0.29	600	700	0.53	900	1,100
10	20	0.01	20	20	0.01	20	20	0.01	100	100	0.01	100	100
290	300	0.12	290	300	0.13	300	330	0.14	300	300	0.17	400	400
860	1,010	0.44	890	1,060	0.49	950	1,160	0.56	1,100	1,300	0.73	1,300	1,500
930	1,090	0.51	1,030	1,200	0.67	1,280	1,570	0.85	1,600	2,000	1.26	2,200	2,600
90	100	0.05	110	120	0.06	120	150	0.08	200	200	0.13	200	300
140	170	0.08	150	180	0.09	180	220	0.11	200	300	0.17	300	400
20	30	0.01	20	30	0.01	20	30	0.01	100	100	0.02	100	100
90	110	0.05	100	120	0.06	120	160	0.08	200	200	0.13	200	300
120	140	0.07	140	170	0.100	200	240	0.130	200	300	0.200	300	400
20	20	0.01	20	20	0.01	30	30	0.01	100	100	0.02	100	100
160	170	0.06	190	200	0.09	220	230	0.10	200	300	0.17	400	400
120	130	0.06	140	150	0.07	170	180	0.09	200	200	0.12	300	400
250	300	0.14	280	340	0.170	330	440	0.220	400	500	0.33	600	700
730	760	0.43	960	1,010	0.71	1,450	1,580	0.96	1,900	2,000	1.30	2,400	2,600
1,590	1,670	0.92	2,040	2,160	1.43	2,980	3,210	1.89	3,700	4,000	3.06	5,600	6,000
1,590	1,670	0.83	1,850	1,960	1.07	2,230	2,400	1.16	2,300	2,500	1.31	2,400	2,600
2,200	2,300	1.00	2,200	2,310	1.00	2,200	2,310	1.00	2,200	2.300	1.00	2,200	2.300
250	260	0.11	250	260	0.12	250	260	0.13	300	300	0.15	300	300
860	900	0.46	1,020	1,080	0.61	1,260	1,360	0.61	1,300	1,400	0.61	1,300	1,400
3,670	3,860	1.96	4,340	4,590	2.73	5,670	6,110	3.44	6,800	7,300	4.59	8,400	9,000
1,590	1,670	1.04	2,300	2,430	1.31	2,730	2,940	2.97	5,900	6,300	6.89	12,600	13,500
1,580	1,870	0.90	1,800	2,160	1.14	2,190	2,670'	1.36	2,600	3,200	1.99	3,400	4,100
130	150	0.07	150	180	0.10	190	230	0.14	300	300	0.25	400	500
40	50	0.02	50	50	0.03	60	80	0.05	100	100	0.10	200	200
10	20	0.01	10	20	0.01	10	20	0.01	100	100	0.01	100	100
150	180	0.08	150	180	0.08	160	200	0.09	200	200	0.13	200	300
9,250	222,810	118.06	256,350	288,610	172.70	354,210	398,600	219.77	415,900	474,600	323.80	573,000	634,400
320	380	0.20	350	410	0.24	390	480	0.30	500	600	0.46	700	800
60	80	0.04	70	80	0.04	70	90	0.05	100	100	0.07	100	100
200	230	0.12	200	240	0.13	220	270	0.16	300	300	0.24	400	400
280	330	0.16	300	350	0.18	300	370	0.20	300	400	0.27	400	500
80	100	0.05	90	100	0.05	90	110	0.06	100	100	0.08	100	100
4,150	4,880	2.60	4,700	5,480	3.27	5,420	6,620	3.96	6,500	7,800	5.70	8,600	10,300
60	70	0.04	60	70	0.04	60	80	0.04	100	100	0.05	100	100
3,570	4,200	2.49	4,500	5,250	3.42	5,670	6,930	4.66	7,600	9,200	6.62	10,000	12,000
39	46	0.02	45	53	0.03	49	60	0.04	57	69	0.04	60	72
4,609	5,436	3.12	5,615	6,553	4.13	6,849	8,390	5.51	9,057	10,869	7 83	11,860	14,072
1,940	2,280	1.34	2,430	2,840	1.89	3,140	3,830	2.45	4,000	4,800	3.68	5,600	6,700
1,940	2,280	1.34	2,430	2,840	1.89	3,140	3,830	2.45	4,000	4,800	3.68	5,600	6,700
410	500	0.40	720	840	0.64	1,060	1,300	0.99	1,600	2,000	1.59	2,400	2,900
68	80	0.05	90	105	0.08	126	154	0.10	171	207	0.13	200	240
478	580	0.45	810	945	0.72	1,186	1,454	1.09	1,771	2,207	1.72	2,600	3,140
2,497	773,016	417.01	920,035	988,728	615.49	1,251,425	1,385,460	797.37	1,543,128	1,708,576	1,139.39	2,019,860	2,215,312

uded

CHAPTER VI

DESIGN CRITERIA

Design criteria have been established to provide a basis for the preliminary development of regional or consolidated systems of intercepting sewers, treatment plants, pumping stations, and force mains.

PROPOSED CONSTRUCTION PROGRAMS

For convenience in estimating when various items of proposed construction will be required, we have arranged the construction programs as follows:

Initial Program	Required by 1975
Future Program	
Stage I	Required between 1975 and 1990
Stage II	Required between 1990 and 2020

Precise timing of future program stages cannot be made at this time because of the many factors affecting such timing, including industrial development, population growth and distribution, availability of water, and funding. Preliminary estimates of the facilities required and the costs involved for the various stages of the recommended regional sewerage plan are presented in Chapters X and XIII.

DEGREE OF TREATMENT

The Texas Water Quality Board (TWQB) requires that treated sewage discharged to all classified bodies of water in the State maintain the standards of general water quality as discussed in Chapter III. The TWQB has established specific requirements for designated water quality zones of the Trinity River and its tributary streams within the study area. The zones are shown on Fig. III-1. Description of the water quality requirements is presented in Appendix A. Discharges of treated sewage to classified waters must be of sufficient quality that they will not impair the existing and potential usage established for these waters.

The minimum degree of sewage treatment allowed by the TWQB is secondary (biological) treatment. In addition, disinfection (chlorination) of effluent is now required except for oxidation pond effluents at all facilities which treat domestic sanitary wastes. As noted in Chapter II, the cities of Dallas and Fort Worth currently are participating in a research project to determine the effect of effluent chlorination on stream quality. The results of that project may have some effect on the requirements for effluent chlorination, but chlorination is included in the treatment facilities proposed herein.

Chlorination is considered necessary not only for the destruction of pathogenic (disease-producing) bacteria in sewage but also to kill viruses causing such diseases as polio, meningitis and hepatitis.

Permits for the disposal of wastes are issued by the TWQB and contain quality and quantity requirements on the waste to be discharged, as discussed in Chapter III. In general, new treatment plants must be designed to produce effluents containing monthly average concentrations of not more than 20 mg/l of BOD and 20 mg/l of total suspended solids.

Primary treatment plants cannot be expected to remove more than 30 to 35 percent of the BOD. Secondary treatment is commonly considered to be obtainable with either activated sludge or trickling filter installations. These plants may be expected to remove up to 90 percent and 85 percent respectively of the BOD, but generally may be expected to remove little or no nutrients such as nitrogen or phosphates. As discussed in Chapter XI, tertiary or advanced treatment for removals of up to about 98 percent of BOD and for the removal of nutrients must be considered for the protection and improvement of lakes and reservoirs used for water supply and recreation, and for streams with little or no flow during extended periods. Techniques for accomplishing advanced waste treatment are discussed in Chapter XI.

BASIS OF TREATMENT PLANT DESIGN

The Texas State Department of Health publication entitled "Design Criteria for Sewerage Systems" has been used in this study. Criteria for secondary treatment facilities contained herein have been adopted. In addition to secondary treatment facilities, tertiary treatment facilities and storm flow treatment facilities (consisting of settling and chlorination) may be necessary to meet the requirements of the receiving waters as discussed in Chapter X. A schematic flow diagram of a sewage treatment plant with all of these facilities is presented on Fig. VI-1. The secondary facilities shown are for the activated sludge process. Trickling filters may also be used for secondary treatment. Different arrangements of the various process units from those shown may be appropriate at a given location. The process indicated is presented for reference only and is not considered as a recommendation.

It is contemplated that all proposed treatment plants should have at least a 20-year design life before requiring modification. Alternative studies, described in Chapter IX, have been conducted based upon both 1990 and 2020 design capacities. All treatment plants proposed for construction as part of the recommended Regional Plan should have the capability of being expanded further to receive and treat flows and loads anticipated in the year 2020.

Rachford et al investigated the expansion of waste treatment systems and determined that there are significant economies of scale in the construction of both sewers and wastewater treatment plants. This consideration lends itself to the concept of regional wastewater collection and treatment systems as discussed in Chapter IX.

The sizing of sewage treatment plants proposed for Initial and Future Stage 1 Construction Programs has been based on average flows and loads anticipated to occur in about the year 1990. The sizing of treatment plants proposed for the Future Stage 2 Construction Program has been based on average flows and loads anticipated in the year 2020. If actual flows and loads fall below those anticipated, plant expansion would be postponed until required.

Proposed treatment plant capacities are considered equal to estimated average daily dry weather flow rates for the design years. We have also considered that during dry weather periods, peak flows (including infiltration allowances) would be taken through the plants.

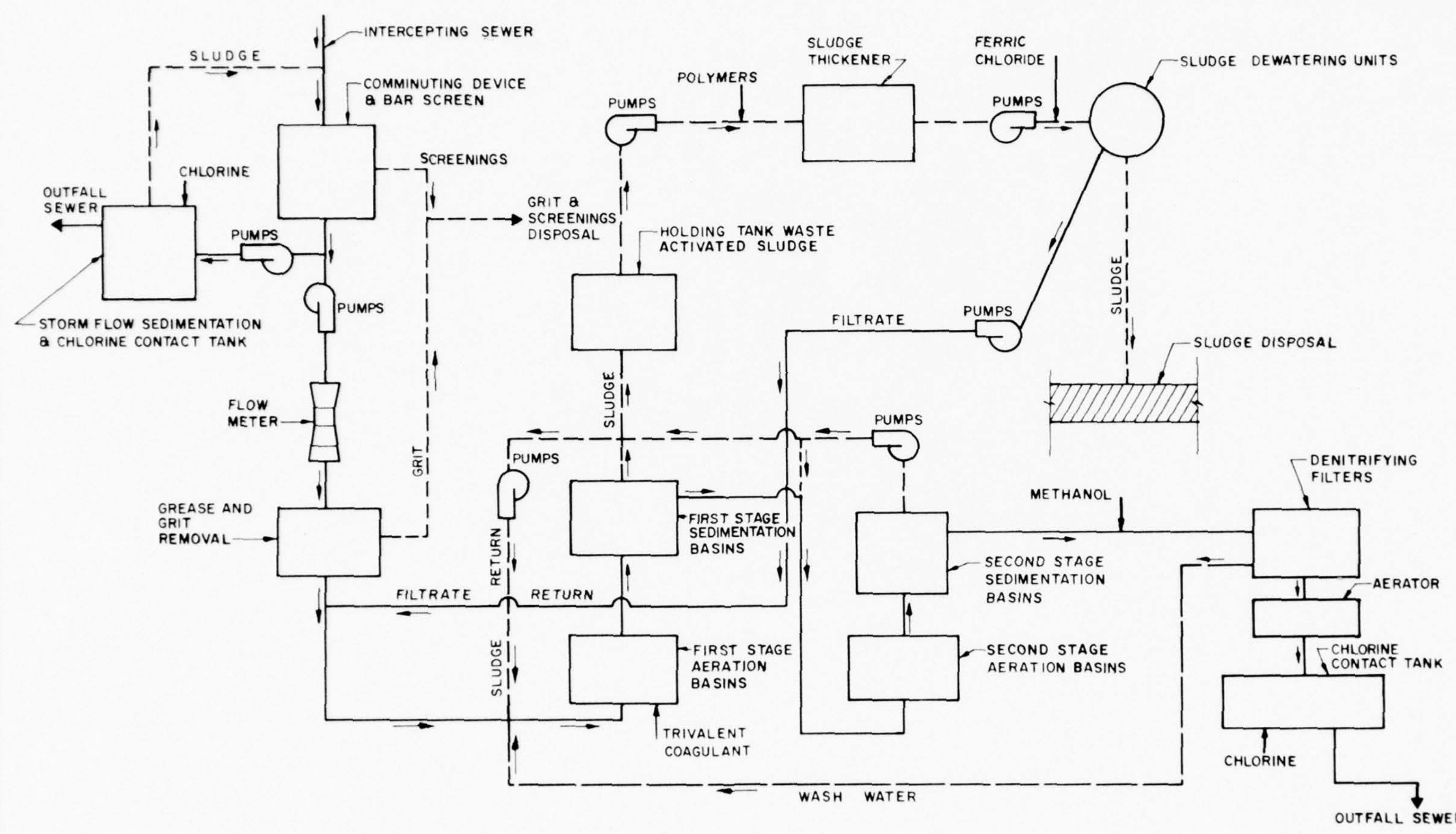


FIG. VI-1 SCHEMATIC DIAGRAM OF SEWAGE TREATMENT PLANT

Wet weather flows exceeding treatment plant capacity will be delivered by the intercepting sewers to a number of plants, particularly in the early years. During wet weather when significant extraneous flows may be expected, flows in excess of peak dry weather flow rates would be diverted through storm flow sedimentation tanks and chlorine contact tanks located either at the treatment plants or upstream in the tributary sewerage systems as required. Such wet weather facilities are now planned in Dallas.

BASIS OF SEWER DESIGN

The design of the proposed intercepting sewers has been based on carrying the tributary peak dry weather flows (sanitary sewage plus an allowance for infiltration) estimated to occur at the end of the design period. Alternative studies, described in Chapter IX, have been conducted based upon both 1990 and 2020 design capacities. However, the relationship between sewer cost and capacity, shown on Fig. VI-2 (derived from cost curves presented on Fig. VII-1), indicates that the increased costs of sewers constructed now with year 2020 capacities are minor as compared with the costs of those constructed with capacities sufficient only for, say, the year 1990. Therefore, a reasonable design year for all proposed sewers is considered to be 2020.

The design of new intercepting sewers has been based on the "seperate plan," under which only wastewater, including unavoidable infiltration, requiring treatment is considered to be taken into the sewerage system. Separate storm inlets and drains must be provided to collect and dispose of the runoff resulting from rainfall. With fully separated systems, stormwater should be excluded to the fullest extent possible from the sewerage system, thereby lessening construction and operating costs for sanitary sewers and treatment facilities and preventing overflows to receiving waters. It is reported that only separate sewer systems have been constructed to date within the study area.

As discussed in Chapter III and V, sanitary sewers should not be designed to accommodate the water from storm drains and roof leaders. It is important that such water be prevented from entering since the amount of water contributed to sanitary sewers from a single catch basin may be many times the amount of the domestic sewage contributed by the plumbing fixtures.

In the design of new intercepting sewers, a ratio of expected future peak dry weather flow (including an infiltration allowance of 75 gpcd) to the flowing full capacity of 0.75 has been used. Resulting pipe sizes have been rounded to the nearest commercially available sizes.

The Texas State Department of Health design criteria have been utilized for preliminary sewer sizing. Pipes have been sized on the basis of average slopes obtained from existing sewer profiles and from topographic maps. In addition, Manning's friction coefficient "n" of 0.013 for existing and new pipes and minimum slopes necessary to produce self-cleansing velocities of about 2.0 fps with the pipes flowing full have been used.

The City of Dallas is currently investigating the use of polymers to reduce wastewater viscosity and increase the carrying capacity of sewer pipes. This investigation might provide in the future a basis on which lower "n" values could be used.

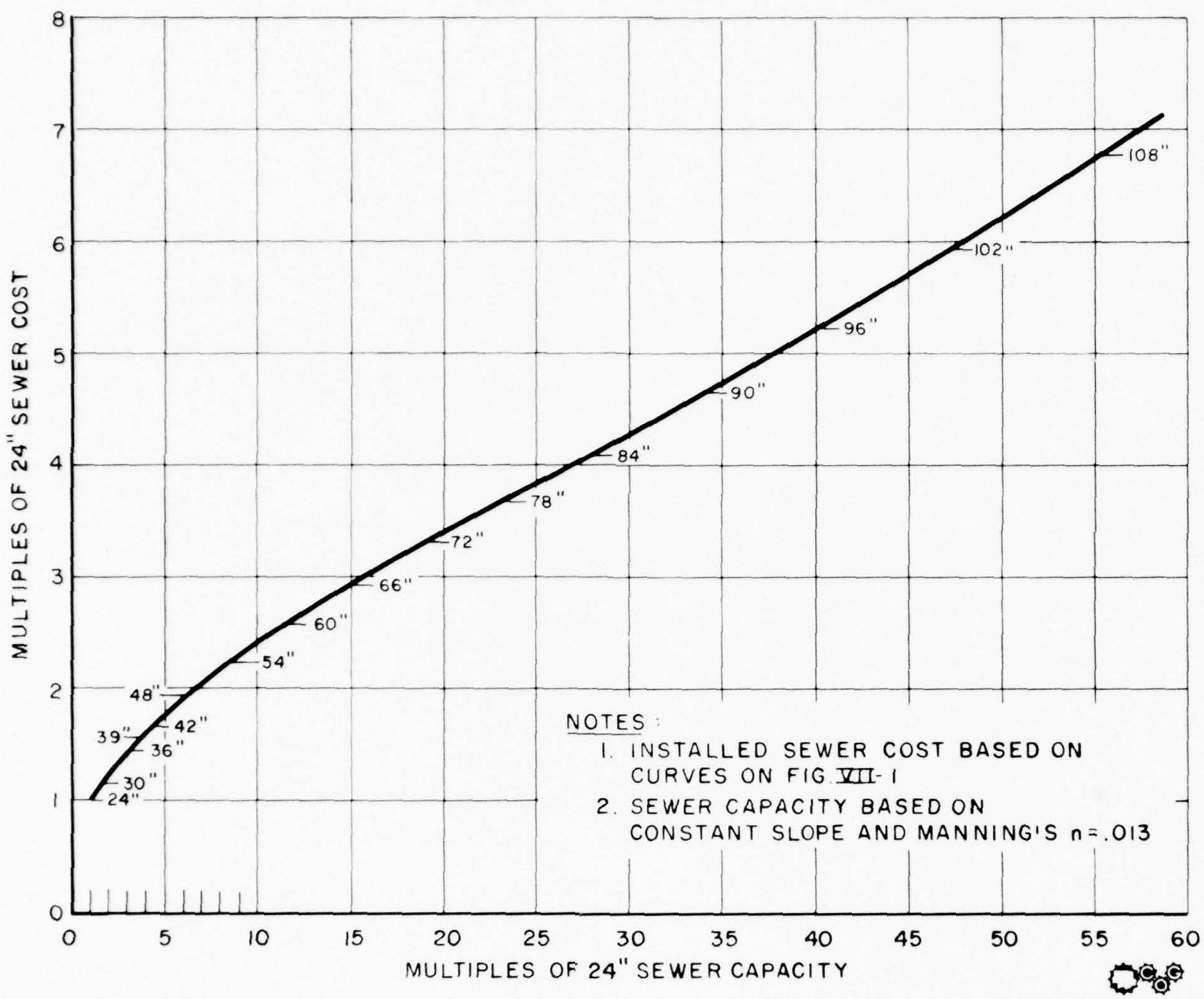


FIG. VI-2 RELATIONSHIP OF INSTALLED SEWER COST TO CAPACITY

The effect of corrosion of pipe caused by hydrogen sulfide gas has been considered. As discussed in Chapter VII, cost estimates for pipe are based on the use of thick wall reinforced concrete pipe. Lining materials, limestone aggregate for concrete pipe and flexible plastic mortar pipe and other corrosion resistant materials may also be used to retard or eliminate the effect of corrosion.

PUMPING STATION AND FORCE MAIN DESIGN

Pumping stations and force mains have been considered to be necessary only where gravity intercepting sewers reach depths of 25 to 30 feet and where flows must be carried over topographic divides. Force mains sizes have been based on estimated peak 2020 design flows, and for convenience friction head losses of 3 feet per 1000 feet have generally been used for a Hazen-Williams "C" value of 120, with a maximum velocity in the force main of about 10 fps. "C" values will tend to decrease with line age, and velocities of 10 fps or more could result in serious surge problems. This head loss has been utilized to achieve reasonable total dynamic heads at pumping stations. The capacity of proposed pumping stations is based upon estimated peak 1990 flows from tributary sewers plus standby pumping capacity. An average standby pumping capacity equal to 33 percent of required capacity has been used. The residence time of sewage in station wet wells should be minimized and odor control measures may be necessary.

ANALYSIS OF EXISTING SEWERAGE SYSTEMS

The projected increases in population and the proposed expansions of the existing sewerage systems require that the adequacy of existing trunk sewers and treatment plants be investigated. These investigations have been made utilizing design criteria described in this chapter. The present adequacy of existing sewage treatment plants in the study area is discussed in Chapter VIII, and the adequacy of existing plants and trunk sewers to meet future requirements in Chapter X.

CHAPTER VII

BASIS OF COST ESTIMATES

DISCUSSION

Preliminary cost estimates have been prepared for construction, operation, and maintenance of proposed sewerage facilities. A series of generalized cost curves has been developed to provide the basis for these estimates and are presented on Fig.VII-1.

Estimated costs of construction of the sewerage facilities considered herein are based on current contractor's bid prices for work of a similar nature in the study area and elsewhere. The costs in this report have been adjusted to an estimated Engineering News-Record (ENR) Construction Cost Index of 1100 for the Dallas area which is slightly above the present index. Recently, however, construction costs have been increasing nationally at a rate of about 10 percent per year, and in the study area costs increased at about 20 percent per year before levelling off around August 1969. Therefore, when up-to-date costs are required in the future, the costs shown in this report must be multiplied by the ratio of the Dallas ENR Construction Cost Index at that future time divided by 1100.

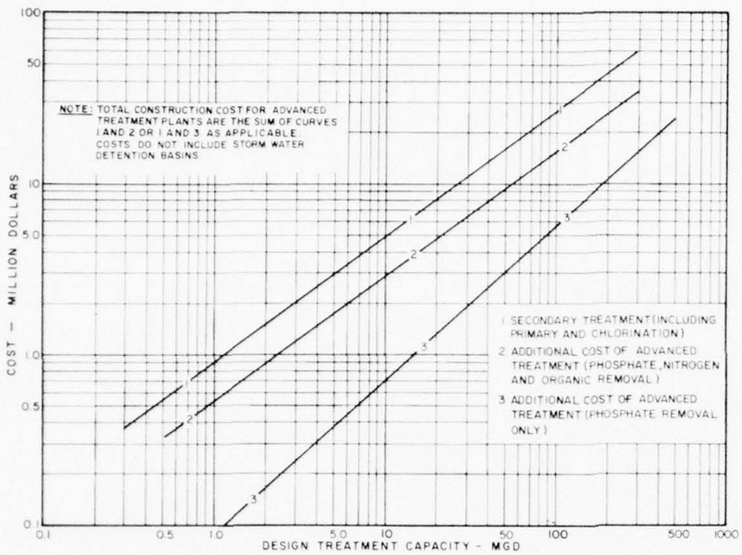
GENERALIZED COSTS

The generalized cost curves of Fig. VII-1 have been developed for sewage treatment plant construction and operation and maintenance costs, sewage pumping station construction and operation and maintenance costs, and force main and sewer construction costs. Considerable cost data have been furnished us by the FWQA Regional Office for this report. Contractor's overhead and profit is included in all construction cost curves. All construction cost curves and estimates in this report include 25 percent allowances for engineering, administrative and legal services during design and construction phases.

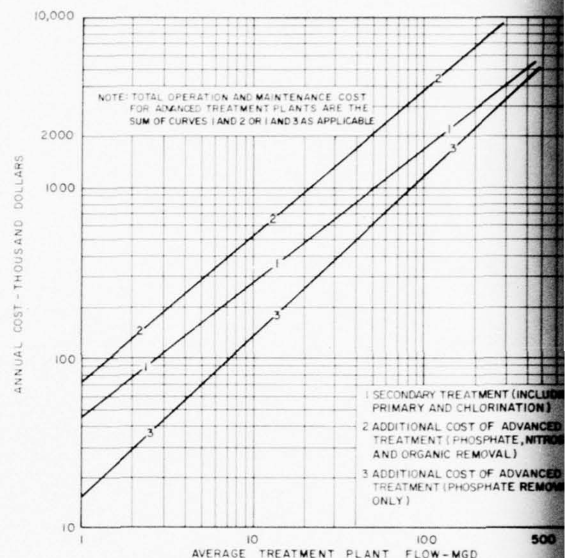
Because specific sites and treatment plant layouts could not be considered in detail in this study, additional studies would be required to develop more reliable costs for each proposed treatment plant. Similarly, detailed studies of intercepting sewers based upon field topographic surveys and subsurface soil data would be required to develop more refined costs.

Land costs (not included in Fig. VII-1) have been considered in addition to construction costs and include the acquisition of land for treatment facilities and pumping stations and for intercepting sewer and force main easements and rights of way. Allowances for land costs at treatment plant and pumping station sites are based on generalized estimates furnished by local authorities. These generalized land acquisition allowances are based on estimated land values in the areas concerned and do not necessarily reflect actual market values of specific sites. An allowance of $2.00 per linear foot (l.f.) has been included for permanent sewer easements.

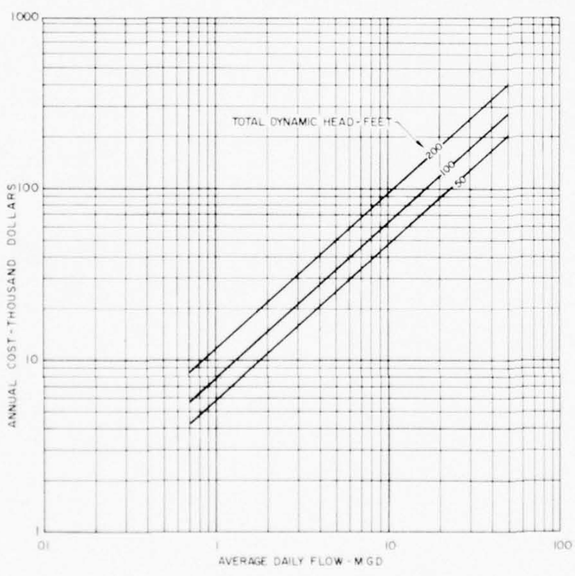
Available subsurface data for the study area were reviewed in connection with the preparation of cost estimates for proposed sewerage facilities. Open cut excavation is considered generally applicable.



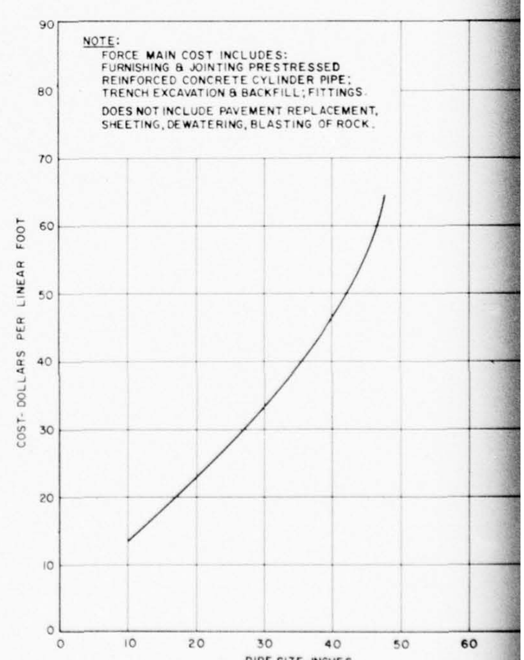
(a) ESTIMATED SEWAGE TREATMENT PLANT CONSTRUCTION COSTS



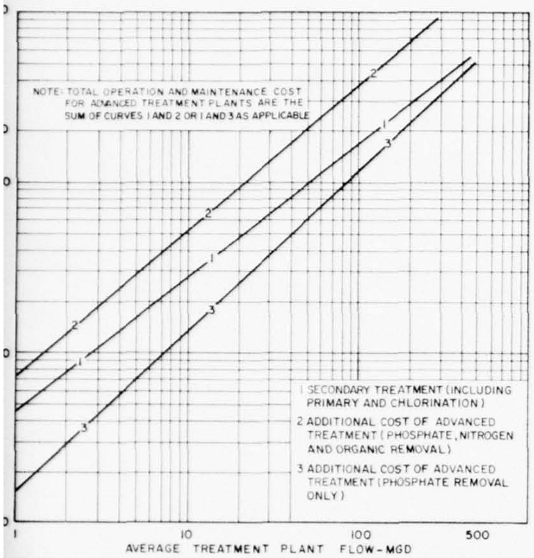
(b) ESTIMATED ANNUAL COSTS FOR SEWAGE TREA
PLANT OPERATION AND MAINTENANCE



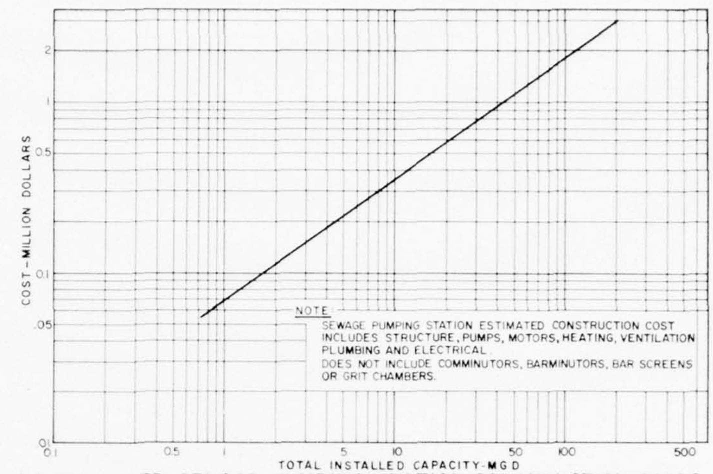
(d) ESTIMATED ANNUAL COSTS FOR SEWAGE PUMPING STATION OPERATION AND MAINTENANCE



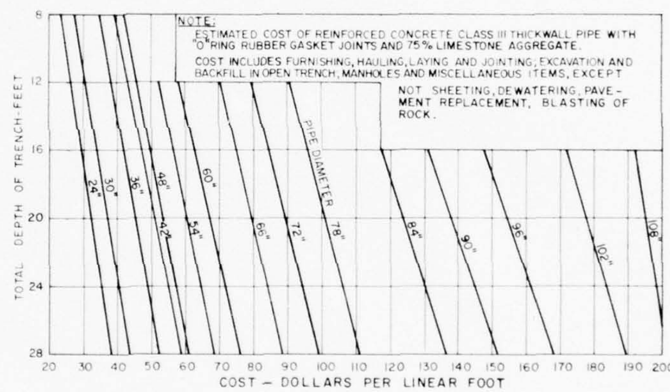
(e) ESTIMATED FORCE MAIN CONSTRUCTION CO



ESTIMATED ANNUAL COSTS FOR SEWAGE TREATMENT PLANT OPERATION AND MAINTENANCE



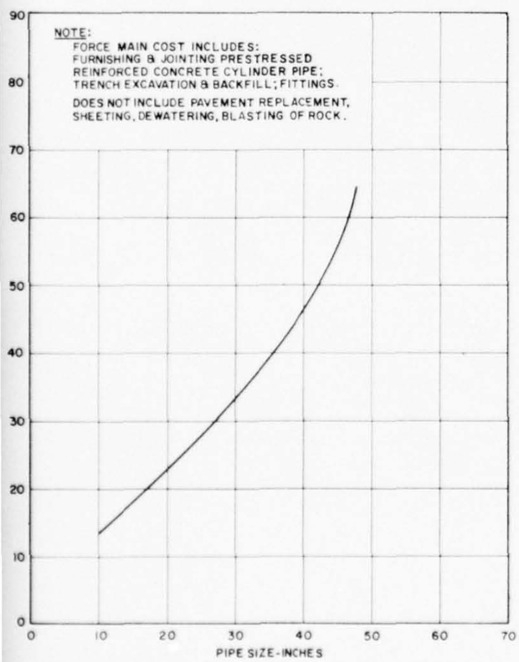
(c) ESTIMATED SEWAGE PUMPING STATION CONSTRUCTION COSTS



(f) ESTIMATED SEWER CONSTRUCTION COSTS

GENERAL NOTES:

1. ALL CONSTRUCTION COST CURVES BASED UPON AN ENGINEERING NEWS-RECORD CONSTRUCTION COST INDEX OF 1100
2. ALL CONSTRUCTION COST CURVES INCLUDE ALLOWANCES FOR ENGINEERING AND CONTINGENCIES
3. OPERATION AND MAINTENANCE COST CURVES ARE CONSIDERED TO BE FOR 1970 CONDITIONS
4. LAND COSTS NOT INCLUDED



(e) ESTIMATED FORCE MAIN CONSTRUCTION COSTS

North Central Texas Council Of Governments
UPPER TRINITY RIVER BASIN
COMPREHENSIVE SEWERAGE PLAN

BASIS OF COST ESTIMATES

CAMP, DRESSER AND MC KEE General Consultants
FORREST AND COTTON, INC. Associate Consultants
FREESE, NICHOLS AND ENDRESS Associate Consultants

JULY 1970 | FIG. VII-1

Generalized cost curves developed for treatment plant and pumping station operation and maintenance are discussed below. Treatment plant operation and maintenance costs include labor, power, chemicals, equipment, and materials. Pumping station costs are based primarily on prevailing labor and electric power rates. Labor rates utilized herein are somewhat higher than the average prevailing rate for skilled personnel, and optimum staffing levels have been assumed. It is recognized that wage rates are currently increasing and that a shortage of skilled labor exists. Electric power rates are estimated at about $0.02 per kilowatt hour (including demand and energy charges).

Annual maintenance costs for intercepting sewers and force mains have been estimated at 0.25 percent of the estimated construction cost for these facilities.

SEWAGE TREATMENT PLANT CONSTRUCTION

Sewage treatment plant construction cost curves are presented on Graph (a) of Fig. VII-1 for secondary plants, together with curves for additional costs of advanced treatment. Secondary treatment plant costs, Curve 1, include the costs of preliminary treatment facilities and are based on adjacent low bids and construction costs for treatment plants in Texas and other parts of the country. The additional cost of advanced treatment (phosphate, nitrogen and organic removal), Curve 2, is based on available cost data on a number of current advanced waste treatment facilities. In addition, we have utilized "A Compilation of Cost Information for Conventional and Advanced Wastewater Treatment Plants and Processes" by Mr. Robert Smith of FWPCA published in December 1967.

The additional cost of advanced treatment (phosphate removal only), Curve 3, is based on cost data developed by the FWPCA for the Lake Michigan Water Pollution Enforcement Conference and published in Environmental Science and Technology magazine in March 1968.

Because of the wide variations in the cost of expanding existing treatment plants, the cost of such expansion is considered to be the same as for a new plant of equivalent capacity. Modern technology may cause actual expansion costs in some cases to be lower than those resulting from the curves shown.

The cost data presented do not include costs for storm flow sedimentation and chlorine contact facilities discussed in Chapter VI.

SEWAGE TREATMENT PLANT OPERATION AND MAINTENANCE

Sewage treatment plant operation and maintenance cost curves are presented on Graph (b) of Fig. VII-1 for the same plant categories as the construction cost curves. The estimated annual operation and maintenance costs include labor, power, equipment, chemicals (lime, ferric chloride, chlorine, etc.), and miscellaneous supplies required. The cost curve for secondary treatment, Curve 1, is based on operation and maintenance costs for such plants in Texas and other parts of the country. Recent annual costs for Dallas and Fort Worth are in general agreement with this curve. Annual costs vary from about $1.00 to $2.00 per capita with the larger Texas cities averaging about $1.00 per person.

The additional annual cost of operation and maintenance for advanced treatment (phosphate, nitrogen and high organic removal), Curve 2, is based on a report by Messrs. Alfred F. Slechta and Gordon L. Culp, "Water Reclamation Studies at South Tahoe Public Utility District" May 1967, published in the Journal of the Water Pollution Control Federation. Additional information for this curve was obtained from Mr. Smith's 1967 compilation for the FWPCA. The costs obtained from this curve must be added to those obtained from Curve 1 to develop total annual operation and maintenance costs for activated sludge plants with phosphate removal.

The additional annual cost of operation and maintenance for tertiary treatment (phosphate removal), Curve 3, is based on the March, 1968 FWPCA data published in "Environmental Science and Technology". The costs obtained from this curve must be added to those from Curve 1 to develop total annual operation and maintenance costs for plants providing full tertiary or advanced wastewater treatment.

PUMPING STATION CONSTRUCTION

Sewage pumping stations discussed herein refer only to those stations that are located physically apart from sewage treatment plants. The estimated costs of the pumping facilities that generally are required in treatment plants have been included in the treatment plant construction costs.

Sewage pumping station construction costs shown on Graph (c) were developed from bids for the construction of pumping stations of various sizes in various locations. These bid costs were adjusted to study area cost conditions.

PUMPING STATION OPERATION AND MAINTENANCE

Sewage pumping station operation and maintenance cost curves are shown on Graph (d) on Fig. VII-1. Costs on this curve are presented on the basis of annual costs, average daily flow, and total dynamic (pumping) head with costs of labor, power, and miscellaneous supplies included. The estimated operation and maintenance costs of the pumping facilities that generally are required in treatment plants have been included in the treatment plant operation and maintenance costs.

Data for these curves were developed from the curve presented in the Marin County, California Report by Brown and Caldwell in 1967 entitled, "Operating Costs of Sewage Pumping Stations", with the costs of attendance labor added and with adjustments to reflect Texas cost conditions.

FORCE MAIN CONSTRUCTION

Force main construction costs shown in Graph (e) were developed from New England bid data and adjusted to Texas cost conditions. Bids from several recent construction projects in the study area compare favorably with this curve.

Off roadway installation has been assumed along with open cut excavation and with excavated material stored trench side. Costs are based on normal excavation, and no allowances have been made for water handling, ledge, boulders, sheeting or pavement replacement. Trench depth has been assumed to permit a minimum cover of 4-ft 0-in for all sizes of pipe.

The cost of excavation has been taken at \$1.25/c.y. Cast-iron pipe costs include hauling, laying and jointing of pipe, and a 5 percent allowance for fittings.

SEWER CONSTRUCTION

Sewer Construction costs shown in Graph (f) were developed from pipe prices furnished by Gifford-Hill Pipe Company. Pipe prices were adjusted to reflect the costs of Class III thick-wall reinforced concrete pipe (delivered to job site) commonly used in the study area to accommodate the effect of crown corrosion due to hydrogen sulfide gas. Costs for hauling, laying and jointing of the pipe were adjusted to reflect study area cost conditions.

The curve reflects off-roadway construction and open cut excavation with excavated material stored trench side. Normal excavation has been allowed and no allowance has been made for sheeting, dewatering, ledge, boulders or pavement replacement. Prices include an allowance for gravel bedding and manholes, as well as contractor's overhead and profit.

CHAPTER VIII

EXISTING PLANT REQUIREMENTS

NEED TO DETERMINE REQUIREMENTS

It is essential in the preparation of a comprehensive sewerage plan to serve the North Central Texas area that existing sewage treatment facilities be given consideration with regards to their potential for future utilization. At present there are an estimated 132 municipal sewage treatment plants serving the population of the study area, and these plants represent a great investment in water pollution control. These plants are described in Chapter IV. It is reasonable to expect that these plants should be utilized in a comprehensive sewerage plan wherever possible.

On the other hand, economy of size and efficiency of operation as discussed in Chapters IX and X indicate clearly the desirability of consolidation of facilities in the Dallas-Fort Worth metropolitan area. Consolidation of plants within this area means the phasing out of a number of existing plants before the end of the design period (year 2020). Some of these plants are currently being enlarged and some are now producing acceptable effluents.

The Texas Water Quality Board (TWQB) issues discharge permits for the discharge of wastewaters into Texas lakes and streams, as discussed in Chapter III. In general, new treatment plants are permitted to discharge to streams and lakes effluents containing monthly average concentrations not exceeding 20 mg/1 of BOD (Biochemical Oxygen Demand) and 20 mg/1 of total suspended solids (SS). In the case of some older plants, requirements have been based on past performance and these requirements are being reviewed by the TWQB with the possibility that they will be brought into line with the requirements for new plants. Discharge flow requirements are also established in the permits.

The TWQB is now requiring the chlorination of treatment plant effluents (except oxidation pond effluents) before discharge to receiving waters, and many plants in the study area do not yet provide chlorination. Not all existing permits now specify chlorination requirements. New permits however frequently specify a chlorine residual concentration in the effluent of 1.0 mg/1 after 20 minutes contact time. Such a residual is considered acceptable in terms of achieving bacterial standards. Consideration should be given by the TWQB to establishing chlorination requirements to achieve virus removal, which would be greater than those for bacteria removal.

Permissible concentrations of nutrients such as phosphates and nitrates in the stream have not been established to date. Nutrient standards should be considered by the TWQB to minimize eutrophication problems as discussed in Chapter III. It is particularly important that plants proposed for enlargement to become joint use plants and other major plants be upgraded to provide effluents meeting nutrient standards as well as present permit requirements.

EXISTING PLANT CAPABILITY

The capability of existing treatment plants to serve as parts of the future area-wide sewerage system is dependent in large measure upon their ability to provide the high quality effluent in keeping with water quality requirements. An evaluation of the existing 132 sewage treatment plants in the study area has been made based upon four considerations as follows:

1. A comparison of site area presently available (owned) with that which might be required for future plant capacity at that same site in the absence of an area-wide or joint system.

2. A comparison of the sewage flow recorded during the year 1968 (or adjacent year) with the allowable flow under its permit.

3. A comparison between the BOD recorded during the year 1968 (or adjacent year) and the BOD allowed under its permit.

4. A comparison of the 1968 (or adjacent year) recorded suspended solids concentration with its permit requirements.

All plants listed in Table VIII-1 have been judged as to their general adequacy under 1968 conditions on the basis of meeting the permitted sewage flow, BOD and suspended solids requirements. If the recorded figures are lower than the permitted amounts in all cases, they are judged to be adequate. While it is recognized that plant records vary from day to day and year to year, if plant recorded data indicate that it fails to meet permit requirements in at least one of these criteria, it is judged to be inadequate. Where insufficient data are available to render a judgment, no statement as to its adequacy is presented. It is recognized that the presence of excessive storm flows results in a reduction of efficiency, but this is not reflected in the adequacy determination. It is important to note that sewage flow rates and strengths generally are increasing year by year, and therefore it may be concluded that some plants listed adequate under 1968 conditions may not be adequate under conditions prevailing in 1970. Generalized land requirements for year 2020 requirements have been estimated based upon site areas needed at existing plants in other areas. No allowance is made for more efficient land use that may result in the future from new treatment processes. Thus, estimated land requirements are considered to be higher than may actually be required.

The adequacy of the six facilities proposed for utilization as joint treatment plants is discussed below.

TRA-TEN MILE CREEK PLANT (1D-161)

The TRA-Ten Mile Creek Treatment Plant is presently under construction, and an evaluation of its efficiency and adequacy must await the receipt of plant operating data. Chlorination facilities are being provided. The site area available is 100 acres whereas 130 acres is expected to be required for the joint facilities to treat the estimated 2020 sewage flow of about 44 mgd.

TABLE VIII-1. ADEQUACY OF EXISTING SEWAGE TREATMENT PLANTS

Node No.	Location[1]	Site Area (acres) Avail-able	Site Area (acres) Required[2] by 2020	Average Flow (mgd) 1968[3] Record	Average Flow (mgd) Permit Allowable	Average BOD (mg/l) 1968[3] Record	Average BOD (mg/l) Permit Allowable	Average SS (mg/l) 1968[3] Record	Average SS (mg/l) Permit Allowable	1968[4] Adequacy
TRINITY RIVER - WATERSHED 1										
1A-211	Kerens		2	0.09	0.14	55	-	56	-	-
1B-92	Sonoma (Ennis System)	4	16	0.31	0.25	40	5.1-20	35	0.1-20	No
1C-90	Nickerson & Nickerson, Inc. (Palmer)			0.003	0.003	-	-	-	-	-
1C-91	Palmer		2	0.04e[7]	0.04	-	201-500		101-200	-
1D-145	Wilmer (A)[5]		11	0.06	0.12	30	5.1-20	128	51-100	No
1D-161	TRA Ten Mile Creek (J)[6]	100	130	-	6.78	-	20	-	20	-
1E-147	Kleberg (A)		15	0.22e	0.50	30	20	46	20	No
1E-149	Balch Springs (Dallas - Hickory Tree WCID #6) (A)	40	17	0.25	0.60	-	20	-	20	-
1E-150	Seagoville Fed. Corr. Inst. (A)		1	0.08	-	-	0.1-5	-	21-50	-
1F-146	Dallas - South Side (J)	640	225	4.00	7.00	40	20	123	20	No
1G-143	Hutchins (A)		5	0.10e	0.18	20	51-100	39	201-500	Yes
1H-66	Richardson (A)	5	10	1.60	4.10	12	50	17	50	Yes
1I-175	Dallas - White Rock (J)	(475[8]		67.20e	(93.8	48	20	46	20	No
1I-176	Dallas (J)		520	33.00		39	20	41	20	No
	Subtotal		954	106.95e						
CEDAR CREEK - WATERSHED 2										
2A-202	Mabank		1	0.05e	0.05	-	-	-	-	-
2A-203	Malakoff		3	0.10	0.13	30	5.1-20	170	0.1-20	No
2A-204	Athens - North	20	5	0.25	1.20	37	20	61	21-50	No
2A-205	Athens - West	46	9	0.30	0.92	21	20	33	20	No
2A-208	Trinidad		2	0.06e	-	19	5.1-20	27	21-50	-
2B-191	Wills Point		2	0.22e	0.21	61	21-50	90	101-200	No
2C-192	Terrell - Kings Creek	38	11	1.60	0.96	44	20	135	20	No
2C-193	Terrell - Bachelor Creek	20	11	0.10e	0.40	14	20	37	20	No
2C-196	Kaufman	4	4	0.41	0.65	60	23	48	46	No
2C-199	Kemp		1	0.05	-	33	5.1-20	39	0.1-20	No
	Subtotal		49	3.14e						
EAST FORK TRINITY RIVER - WATERSHED 3										
3A-58	Seagoville (A)		15	0.19e	0.68	80	5	52	50	No
3A-61	Crandall		1	0.04e	0.07	38	5.1-20	26	0.1-20	No
3B-15	Farmersville		2	0.19e	-	45	-	34	-	-
3B-16	Rockwall (A)	6	16	0.14e	0.60	85	20	20	20	No
3B-51	Forney		3	0.20e	-	-	-	-	-	-
3C-54	Mesquite (A)	384	60	4.80	1.96	18	25	24	20	No
3D-23	Garland - Duck Creek (J)	138	400	9.80	10.00	27	20	36	20	No
3E-26	Plano (A)	27	106	1.50	0.50	24	20	38	20	No
3F-40	Garland - Rowlett Creek (A)	109	72	2.70	2.00	27	20	45	20	No
3G-34	Wylie (A)		7	0.13e	0.15	-	20	-	50	-
3H-1	Anna		1	0.04e	-	-	-	-	-	-
3H-3	McKinney - North (A)	4	1	0.25	0.20	18	20	16	20	No
3H-24	McKinney - South (A)	170	31	1.25	1.27	16.5	20	16	90	Yes
3I-0	Van Alstyne		2	0.21	0.05	34	0.1-5.0	55	0.1-20	No
3I-5	Princeton		1	0.07e	0.07	33	50	117	50	No
3J-7	Tom Bean		1	0.03e	-	-	0.1-5	-	101-200	-
3J-8	Blue Ridge		3	0.02e	0.14	-	30	-	50	-
3J-11	Trenton		1	0.02e	0.06	21	5.1-20	62	0.1-20	No
3J-14	Leonard		1	0.07e	-	13	-	32	-	-
	Subtotal		724	21.65e						
ELM FORK TRINITY RIVER - WATERSHED 4										
4A-81	Lewisville (A)	24	14	0.60	0.80	30	20	24	70	Yes
4A-166	TRA Central (J)	490	640	13.60	30.00	23	20	53	100	No
4B-149	J. W. Helton (Justin)			-	0.01	-	-	-	-	-
4B-150	Justin		4	0.05	-	3	-	38	-	-
4B-151	Roanoke		4	0.04	0.07	-	51-100	-	20	-
4B-156	Grapevine (A)		36	0.29	-	15	-	30	-	-
4B-170	Green Acres Estates (A)		-	-	0.03	-	-	-	-	-
4C-50	Muenster		4	0.14	0.16	40	35	151	90	No
4C-53	Lindsay		4	0.02	-	61	-	71	-	-
4C-55	Gainesville		14	1.39	1.23	48	20	50	20	No
4C-70A	Lake Dallas		-	0.50	-	20	20	20	20	-
4C-71	Denton	18	50	2.60	6.00	15	20	31	20	No
4C-206	Prosper		4	0.02	-	16	-	157	-	-
4C-209	Frisco		4	0.07	-	13	20	10	20	-
4D-100	Krum		4	0.03	0.08	-	20	-	20	-
4E-10	Sanger		4	0.11	1.00	136	51-100	85	-	No
4E-11	Nickerson & Nickerson, Inc. (Sanger)			0.003	0.003	-	-	-	-	-
4F-60	Pilot Point		4	0.11	0.09	-	20	-	20	No
4F-64	Aubrey		4	0.04	-	40	-	126	-	-
4F-200	Gunter		4	0.05	-	50	-	82	-	-
4F-204	Celina		4	0.08	0.08	23	-	85	-	-
4G-213	Collinsville		4	0.06	0.09	23	51-100	90	51-100	Yes
4G-214	Tioga		4	0.04	-	35	-	25	-	-
	Subtotal		810	20.96e						
WEST FORK TRINITY RIVER - WATERSHED 5										
5A-20	Keller (N.Tarrant Co. M.W.D.)(A)			-	0.12	-	-	-	-	-
5A-24	Grapevine (A)			-	-	-	20	-	20	-
5A-60	Greenview Addition (A)			-	-	-	-	-	-	-
5B-170	Green Valley Mobile Home Park (Smithfield)(A)			-	0.02	-	-	-	-	-
5C-1	Venus			0.03	-	55	-	163	-	-
5C-500	Midlothian		6	0.10	0.40	25	100	44	50	Yes
5D-214	Mansfield			0.20	0.32	-	20	-	20	-
5E-195	Arlington (A)	42	170	5.41	6.50	52	20	45	20	No

TABLE VIII-1. ADEQUACY OF EXISTING SEWAGE TREATMENT PLANTS
(Continued)

Node No.	Location[1]	Site Area (acres) Avail-able	Required[2] by 2020	Average Flow (mgd) 1968[3] Record	Permit Allowable	Average BOD (mg/l) 1968[3] Record	Permit Allowable	Average SS (mg/l) 1968[3] Record	Permit Allowable	1968[4] adequacy
WEST FORK TRINITY RIVER - WATERSHED 5 (Continued)										
5F-184	Euless - West (A)			1.50e	-	-	-	-	-	No
5F-188	Euless - East (A)			1.00e	-	-	-	-	-	No
5F-189	Greater Southwest (A)			0.04	-	-	-	-	-	-
5G-130	Burleson (A)		5.0	0.26	0.60	50	20	46	30	No
5G-132	Crowley (A)		5.4	0.08	-	-	-	-	-	-
5G-133	Sunny Acres Mobile Home Park (Crowley (A)		-	-	0.03	-	-	-	-	-
5G-136	Everman (A)		4.0	0.19	0.13	8	21-50	32	21-50	No
5G-137	Kennedale (A)		22.0	0.14	2.00	6	21-50	10	20	Yes
5G-138	Forest Hill (A)		16.0	0.70	0.41	21	21-50	10	20	Yes
5G-180	Fort Worth - Village Creek (J)	347	750	26.70	30.00	35	20	48	20	No
5H-141	Banfield Mobile Home Park (A)		4.0	-	-	-	-	-	-	-
5H-143	Royal Coach Mobile Home Park (A)		7.5	-	-	-	-	-	-	-
5H-145	L & M Mobile Home Park (A)		4.0	-	-	-	-	-	-	-
5H-150	Treetop South Mobile Home Park (A)		6.0	-	-	-	-	-	-	-
5H-153	Tumbleweed Mobile Home Park (A)		6.6	-	-	-	-	-	-	-
5H-156	Wilson Mobile Home Park (A)		4.7	-	-	-	-	-	-	-
5H-159	Poly-Webb Mobile Home Park (A)		-	-	0.01	-	-	-	-	-
5I-17	Keller Mobile Home Park (A)		-	0.001	0.008	-	-	-	-	-
5J-107	Haltom City (A)		66.0	1.62 (9)	1.20	32	21-50	35	21-50	No
5J-112	Richland Hills (TCWSC #2) (A)		5.0	0.46	-	145	-	156	-	-
5M-101	Fort Worth - Riverside (A)	160	-	25.40	30.00	28	30	35	55	Yes
5M-172	TCWSC #1 (Highway 820) (A)		5.0	1.39	-	-	-	-	-	-
5Q-71	Benbrook (A)		18.0	0.28	-	8	20	234	20	No
5Q-72	St. Francis Village		4.0	0.05	-	20	20	34	20	No
5Q-73	Weatherford		16.0	0.75	0.73	24	20	12	20	No
5Q-76	Aledo		4.0	0.01	-	-	-	-	-	-
5S-18	Chico		5.8	0.05	0.25	35	20	42	20	No
5S-19	Bridgeport		5.6	0.39	-	60	-	140	-	-
5S-23	Runaway Bay		4.0	0.003	0.20	3	20	11	20	Yes
5S-38	Jacksboro		4.0	0.31	-	26	-	39	-	-
5S-39	Decatur		4.5	0.21	0.18	20	21-50	30	51-100	No
5S-46	Boyd		4.0	0.05	0.03	44	20	84	51-100	No
5S-51	Rhome		-	0.005	0.08	-	-	-	-	-
5S-52	Springtown		4.0	0.14	0.12	85	20	-	20	No
5S-59	Lakeside (A)		5.0	0.10	-	-	-	-	-	-
5S-175	Azle TCWSC (A)		-	-	-	-	-	-	-	-
5T-1	Bowie - South		2.5	0.10	0.50	16	20	16	20	No
5T-28	Bowie - East		5.0	0.30	0.20	40	20	50	20	-
5T-11	Alvord		4.0	0.06	-	19	-	192	-	No
	Subtotal		1,185.60	67.93e						
NOLANDS CREEK - WATERSHED 8										
8A-1	Johnson Co. FWSD #1 (Joshua)			0.048	0.13	-	-	-	-	-
8A-2	Cleburne			1.36	-	86	-	50	-	-
8A-3	Godley			0.011	0.04	-	-	-	-	-
	Subtotal			1.42						
CHAMBERS CREEK - WATERSHED 10										
10A-80	Alvarado		2	0.09	-	27	-	29	-	-
10A-81	Maypearl		3	0.03e	0.02	50	50	47	200	No
10A-82	Keene			0.125	0.03	-	-	-	-	-
10A-83	Grandview		1	0.08e	-	23	-	28	-	-
10A-84	Italy		1	0.09e	-	-	-	-	-	-
10A-85	Avalon - W.S.& S. Corp.(Italy)		-	-	0.41	-	-	-	-	-
10A-86	Milford		1	0.05e	0.04	-	100	-	100	No
10A-97	Corsicana(10)		19	2.62	2.95	-	5.1-20	-	51-100	-
10A-99	Forreston	1	1	-	0.03	-	20	-	20	-
10B-89	Waxahachie	15	23	0.95	0.96	65	20	30	50	No
10B-90	Wayside Mobile Home Park (Waxahachie)		-	-	0.02	-	-	-	-	-
10B-544	Bardwell		1	-	0.02	-	20	-	20	-
	Subtotal		33	1.42e						
CUMMINS CREEK - WATERSHED 11										
11A-94	Ennis (Oak Grove)	4	19	0.75	0.53	20.5	37	43	90	No
SABINE RIVER - WATERSHED 12										
12A-10	Fate			-	0.04	-	-	-	-	-
12A-18	Royse City	4	6	-	-	-	-	-	-	-
12A-501	Josephine		1	-	-	-	-	-	-	-
	Subtotal		7							
	Grand Total		3,781.6	224.22						

Notes:

(1) See Figs. IV-1 and IV-2.
(2) Based on estimated plant size:
  a. Area for joint plants reflects recommended regional plan requirements (Chapter X).
  b. Area for other plants would apply in absence of recommended regional plan.
(3) See Table IV-1.
(4) Based on meeting flow, BOD, and SS requirements.
(5) (A) - Plant to be phased out by 2020 under recommended plan.
(6) (J) - Plant to be expanded into joint plant under recommended plan.
(7) e - estimated.
(8) Includes land for both the Dallas and White Rock plants.
(9) Flow reduced to 0.50 mgd in 1969.
(10) Data for Corsicana represent the total of both existing plants which are located outside of study area and are not included in watershed totals or the grand total.

DALLAS-SOUTH SIDE PLANT (1F-146)

The Dallas-South Side Treatment Plant is planned for expansion in the near future when flows from the Five Mile Creek area and other areas are diverted into it. Records indicate that average effluent concentrations from the existing oxidation ponds do not meet permit requirements, and no chlorination is provided. Land area available is about 640 acres and is considered ample for any foreseeable requirements. The estimated land requirements for facilities to serve estimated year 2020 flows of about 80.5 mgd is about 225 acres.

DALLAS-WHITE ROCK PLANTS (1I-175, 1I-176)

The Dallas and White Rock Plant records indicate that they do not meet permit requirements for average flow, BOD, or SS. In July, 1970, chlorination of effluents is scheduled to begin. Future flows from some tributary areas are expected to be diverted to the Dallas South Side Plant. Land area available at the Dallas-White Rock site is about 475 acres, and the area estimated to be required by facilities to serve the estimated 2020 sewage flow of 200 mgd is about 520 acres. The additional land area actually needed (if any) will depend on process changes and the flows diverted to the South Side Plant.

GARLAND-DUCK CREEK PLANT (3D-23)

The Garland-Duck Creek Treatment Plant is currently being considered for expansion from its existing capacity of 10 mgd up to 30 mgd. Expansion is necessary because average flows in 1969 exceeded design capacity. In 1968 the plant effluent did not meet permitted BOD and SS concentrations. The existing land area available at this site is about 130 acres, and the land requirement for facilities to serve the estimated year 2020 flow of about 155 mgd is about 400 acres.

TRA-CENTRAL PLANT (4A-166)

The TRA-Central Treatment Plant is currently operating well within its permitted average flow rate. It also meets the SS requirements of 100 mg/l but does not meet the BOD requirements based on its 1968 record. No effluent chlorination is provided at this plant. The present available site aland area is about 490 acres. For the estimated year 2020 sewage flow of 256.00 mgd the anticipated land requirements are about 640 acres.

FORT WORTH-VILLAGE CREEK PLANT (5G-180)

The Fort Worth Village Creek Treatment Plant is currently being expanded from 30 mgd to 45 mgd capacity. When this plant is further expanded as planned by the City, the existing Riverside Treatment Plant will be phased out. Based on 1968 records the Village Creek Plant did not meet permitted BOD and SS concentrations. In July, 1970, chlorination of the Riverside plant effluent is scheduled to begin. The present land area of the Village Creek Plant (including sludge drying beds) is about 347 acres. The land requirement for facilities to handle the estimated year 2020 sewage flow of about 299 mgd is about 750 acres.

CONCLUSIONS

With reference to Table VIII-1 evaluation of the adequacy of existing sewage treatment plants in the study area indicates that of the 132 existing plants only ten meet all the criteria presented above. Fifty-one of the plants are judged to be inadequate under 1968 conditions and the current TWQB permit requirements. Of these fifty-one, fifteen are, as noted on Table VIII-1, scheduled to be phased out when joint-use facilities are constructed. The remaining thirty-six (which include six joint-use plants) should be upgraded. Data on the remaining 71 plants were not considered sufficient to make a determination.

None of the six operating plants proposed to be expanded into joint treatment facilities as part of the recommended plan meets present State requirements, which include chlorination.

It is evident that six treatment plants recommended to be expanded to become joint facilities as part of the recommended plan and other major plants must be upgraded in order to meet present permit requirements. In order for these plants to meet future water quality requirements not only will average flow, BOD, and SS requirements have to be met, but in our opinion, concentrations of nutrients and dissolved oxygen in their effluents will also require control. In general, there does not appear to be a serious problem with regard to land available for future sewage treatment plant expansion requirements; however, adequate land to provide facilities for future needs should be set aside at an early date to preclude its possible use for other purposes.

CHAPTER IX

ALTERNATIVE REGIONAL SEWERAGE SYSTEMS

GENERAL CONSIDERATIONS

The large number of sewage treatment plants scattered throughout the Upper Trinity River Basin suggests the possibility of greater consolidation of such facilities in the interests of greater efficiency and economy. This chapter summarizes the investigation conducted to evaluate alternative means of providing sewerage facilities for the study area. A preliminary investigation was made for each major watershed within the study area to determine the most favorable systems for analysis. In general, the basic objective of the analysis is to determine the most advantageous alternatives, without regard to political or water pricing budgetary constraints, with least cost being one basis for the selection of recommended sewerage systems. The suggested means of administration for the recommended plan, including methods of financing, operation, and maintenance, are discussed in Chapter XII.

A considerable variety and quantity of information is required for the investigation and selection of sewerage systems to serve an area as great as the North Central Texas region. Such engineering information includes the following: (a) location, capacity and condition of existing sewage treatment plants and trunk sewers; (b) water quality standards for the Trinity River and associated tributaries and reservoirs; (c) projections of future sewage flows and loadings for population centers; (d) design criteria and cost estimates for sewage treatment plants, interceptors, pumping stations, and force mains. In addition, the topography of the region is significant in the selection of possible routes for interceptors and force mains.

The first portion of this chapter, together with Appendix F, describes a mathematical model which employs the computer to analyze a tentative or trial network of sewerage facilities and determine, on the basis of cost, the following items:

1. Number, location, and capacity of sewage treatment plants (local, joint, or regional). As used herein, the term "joint plant" refers to a plant which serves two or more population centers, and the term "regional plant" refers to a plant which serves two or more watersheds.

2. Route and capacity for the interceptors and force mains associated with joint or regional sewage treatment plants.

The final portions of this chapter describe the analyses and recommended alternatives for the various watersheds within the study area. A more comprehensive discussion of the recommended alternatives is contained in Chapter X.

SYSTEMS ANALYSIS STUDY

GENERAL

The economy of size for treatment plants is the feature of primary importance in the economic analysis of regional sewerage systems; i.e., the cost *per unit of capacity* decreases as the total capacity increases. For example, if the capacity of a secondary

treatment plant (expressed in terms of average daily flow in mgd) is doubled, the total construction cost per mgd of capacity decreases by approximately 20 percent as shown on Fig. VII-1. Likewise, operation and maintenance costs per unit of capacity decreases as plant capacity increases. Thus, it is considered economical to transport sewage to a joint or regional treatment plant, if the total cost of transmission (interceptors, force mains, and pumping stations) plus the cost of the plant is less than the total cost of several smaller treatment plants at collection points near the population centers.

Similarly, the costs of transmission facilities reflect economy of size; doubling the capacity of a gravity-flow sewer reduces the total cost per unit of capacity by approximately 30 percent as shown on Fig. VI-2. The same general effect is seen in the costs for pumping stations and force mains.

Generally it is not economical to carry consolidation to the extreme of building one huge plant for an entire region, with interceptors running through miles of open country to serve sparsely populated villages. Limited consolidation, however, with urban areas served by joint systems and rural communities served by separate local treatment plants, appears to be a logical objective.

To determine the most economical alternative, it is desirable to examine many possible combinations of sewage sources and locations for regional treatment plants. The electronic computer is a valuable aid in performing this function.

For the purpose of cost comparison, the average annual cost including capital, land, operation, and maintenance costs was used, rather than total present-worth capital cost, to provide easier comprehension of the results. Generalized cost curves for each type of facility are contained in Chapter VII. It was assumed that bonds for capital construction costs are repaid at a given interest rate and that equal portions of the principal are repaid annually over a period of 30 years. Although 6-1/2 percent appears to reflect the current market, and has been used in most of the studies, interest rates of 5-1/2 percent and 7-1/2 percent have been employed in several cases to examine the sensitivity of the results to changes in the interest rate. Since annual interest payments on the unpaid balance decrease uniformly over the thirty-year period, the average annual cost for construction was computed as the average of the 30 annual payments. Average annual costs of operation, maintenance, and power for treatment plants and pumping stations were computed from the average annual sewage flows over a design period. Design periods considered cover the time spans 1975-1990 and 1975-2020.

MATHEMATICAL MODEL

The design criteria and unit cost estimates for the various types of facilities have been presented in Chapters V,VI, and VII. These data have been adapted for the mathematical model and are summarized below.

Treatment Plants. The generalized cost curves for treatment plants, presented in Chapter VII, show that cost as a function of capacity can be described by a straight line on a log-log plot. The average annual cost can then be computed by the following equation:

$$C = ACF\ aQ^{b} + cQ^{d}$$

where C = Average annual cost of a treatment plant, in $1,000/year;

ACF = Annual cost factor to transform the construction cost to an equivalent annual cost;

Q = Capacity of treatment plant, in mgd;

a,b = Numerical constants describing the construction cost curve. (If the cost of land is excluded, a = 900, b= 0.735 for secondary treatment);

Q = Average annual sewage flow over the design period, in mgd;

c,d = Numerical constants describing the cost curve for operation and maintenance. (For secondary treatment, c = 46, d= 0.778).

The cost of land in dollars per acre must be estimated separately for each treatment plant site, while the land requirement in acres can be estimated as a function of plant size. For each site, the total cost of land was converted to an equivalent annual cost and added to the value of C to obtain the total annual cost.

Interceptors. The generalized construction cost for interceptors in dollars per foot of length for each standard sewer size was included in the input data. For sewer size, an average depth of cover (depth from ground surface to sewer crown elevation) equal to 12 feet was assumed. The estimated cost of land easements for sewers was considered to be $2 per linear foot, (l.f.), and the estimated annual cost of maintenance was based on 0.25 percent of the construction cost. For diameters greater than 108-in, the cost was assumed to increase linearly with the diameter. Instead of circular conduits of such size shapes other than circular are sometimes utilized, and multiple-barrelled conduits may be employed.

The peak dry weather flow in mgd (Qd), as a function of the average daily flow (Q), was estimated from the formula:

$$Qd = 3.8\ Q^{.823}$$

This relationship is a close approximation of the curve presented in Fig. V-5. An additional allowance of 75 gallons per capita per day (gpcd) for peak infiltration was assumed in obtaining the design peak flow. The required sewer capacity was obtained by dividing the design peak flow by the factor 0.75. However, the sewer capacity selected is subject to the restrictions described below.

Sewer diameters were computed from the Manning formula using an "n" value of 0.013. For a given value of slope, the diameter corresponding to the required sewer capacity was then computed. A larger diameter was selected, if necessary, to obtain a scouring velocity of 2 fps when the sewer is flowing full or half full. In addition, a minimum allowable diameter of 24-in was used in selecting sewer sizes for interceptors and relief trunks considered in this study. The full capacities of existing trunk sewers were utilized before relief trunks were considered necessary.

In the computer analysis, sewer diameters were considered to vary continuously, rather than in discrete jumps corresponding to the standard sized of 24-in, 30-in, 36-in, etc. After the cost-minimization procedure was completed, standard sizes were selected.

Pumping Stations. The design peak flows for pumping stations were computed in the same manner as for sewers, described above. The installed capacity was computed by multiplying the design peak flow by 4/3, to allow for installation of standby pumps. The average annual costs for construction, operation, and maintenance were computed from generalized cost curves in a form similar to that described above for treatment plants.

Average annual power costs were computed from the average annual flows and average total dynamic head. The static head for each pump station was given in the input data, and the friction head was computed using the length and size of the force main, as discussed below.

Force Mains. The construction cost per linear foot as a function of diameter was computed using the design peak flow, the Hazen-Williams formula with a roughness coefficient C= 120, and a head loss of 3 ft per 1,000 ft length. For diameters greater than 48 in, the cost is assumed to increase linearly with the diameter.

Representation of Sewerage Systems. A sewerage system is considered to consist of a geographical distribution of collection or loading points for locally-generated sewage flows actually or potentially linked together in a tree-like formation by gravity and pressure interceptors which transmit flows from collection points on the "twigs" of the "tree" via the "branches" to the "trunk," on which a sewage treatment plant may be situated, as shown on Fig. IX-1, Appendix F. More precisely, the system is defined in terms of "nodes" and "links." A node may be a collection point for the sewage from a local municipality, a treatment plant site, a junction where two or more interceptors meet, or a combination of these items. It may also be considered as a loading point. A link is considered to be an interceptor joining two nodes; it may comprise, in series, several gravity interceptor segments of varying slopes and lengths, and/or several pumping stations and pressure interceptors.

Economic Analysis. The objective of the economic analysis is to determine the minimum-cost combination of links and nodes. This analysis is referred to as an optimization procedure. At each node, the choice must be made between two alternatives: construction of a treatment plant at the node to treat the total sewage inflow (local inflows plus flows from upstream nodes); or construction of facilities to carry the total sewage inflow to the next downstream node. Several common techniques of systems analysis might be considered as possible methods of economic analysis for the problem at hand, of which linear programming and dynamic programming are the most attractive. Linear programming has been selected as the most applicable method for this study. A description of the linear programming procedure is contained in Appendix F.

The input data for each collection point consists of the following:

1. The projected local sewage inflows to the collection point for the

years 1975, 1990, and 2020. The different types of facilities are designed for full utilization at the end of their respective design periods. The combinations of design periods used in this study are:

a. Treatment plants and pumping stations designed for the period 1975 to 1990 (with provisions for expansion after 1990). Interceptors and force mains designed for year 2020. (As discussed in Chapter VI, this combination is recommended).

b. All facilities designed for the period 1975 to 1990.

c. All facilities designed for the period 1975 to 2020.

2. The local contributory populations for the node in 1990 and 2020. These values are used to estimate the peak infiltration flows for pumping stations, interceptors, and force mains.

3. The type of treatment facilities (secondary or advanced) installed at the node, if the node is selected as a plant site. Alternatively, the node may be designed as an unsuitable location for a treatment plant.

4. An assumed allowance for the cost of land in dollars per acre for the treatment plant site at each node. Although the land cost is usually a minor item in the total cost, the cost of land is included in the total cost of a treatment plant for the purpose of cost comparisons.

5. The capacity of an existing treatment plant at the node. In the program computations, it is assumed that all existing plants provide secondary treatment, and may continue in operation (with expansion if necessary) until 1990, if the node is selected as a treatment plant site. If the node is included in a joint collection system, the existing plant is considered to be phased out. For secondary treatment, the construction and land costs for plant expansion are based on the additional required capacity, while the annual cost of operation and maintenance is computed using the total sewage inflow to the plant. For tertiary treatment, the additional costs of construction, operation, and maintenance are based on the total estimated inflow to the plant.

The input data for a link consist of the slope and length of each gravity interceptor segment, and the static pumping head and length of each pressure interceptor or force main. For a link that represents a relief interceptor laid parallel to an existing interceptor, the full capacity of the existing interceptor is considered to be utilized and is also included in the input data.

CONSIDERATIONS IN THE SELECTION OF SYSTEMS

FACTORS INFLUENCING THE COST COMPARISONS

The East Fork Trinity and West Fork Trinity Watersheds have been used as examples to examine the effects of several significant factors on the selection of regional and joint sewerage systems. The factors considered are:

1. Required degree of treatment (secondary or advanced).

2. Interest rates on construction bonds.

3. Design periods for the different facilities.

4. Utilization of existing treatment plants.

5. Federal and State financial assistance.

The estimated costs of the alternative systems, for selected combinations of the factors under consideration, are shown in Tables IX-1 and IX-2. (Unpaid or outstanding debts on existing facilities, and costs for expanding treatment plants and pumping stations in 1990 to 2020 capacity are not included in the costs shown). Of the four alternatives selected for the East Fork Trinity Watershed, Alternative A is equivalent to continuation of the present system; Alternatives B, C, and D correspond with increasing consolidation of treatment. The joint sewerage sytems associated with Alternatives A, B, C, and D would handle approximately 40 percent, 80 percent, 98 percent, and 98 percent respectively, of the estimated 1990 total sewage flow generated in the East Fork Watershed. For the West Fork Watershed, the joint sewerage systems for Alternatives A, B, and C would handle approximately 80 percent, 96 percent, and 100 percent respectively, of the total sewage flows within the watershed. In all cases, the remaining flows in the respective watersheds would be treated by separate local plants.

The sensitivity of the cost comparisons with respect to the required degree of treatment, the interest rate, and the design period is shown in Table IX-1. The total average annual costs listed in the table for each alternative include the amortized capital cost for construction of all facilities in the respective watersheds, and the annual costs of operation and maintenance. No allowances for utilization of existing treatment plants, nor for Federal and State financial assistance have been made in this table. Table IX-2, discussed below contains cost comparisons which demonstrate the effect of utilizing the capacity of existing treatment plants.

Required Degree of Treatment. At present, a minimum of secondary treatment must be provided by the existing treatment plants in the study area. If it is considered that only secondary treatment is to be provided in the future considerable quantities of water for low flow augmentation would be required to attain river quality standards. Since water for low flow augmentation is difficult to obtain, advanced wastewater treatment appears to be a general requirement particulary for the larger plants, if water quality requirements are to be met. Low-flow augmentation requirements for secondary treatment are presented in Chapter X.

From the cost comparisons in Table IX-1, it is apparent that the required degree of treatment has a strong influence on the relative costs of the alternatives, and on the magnitude of the total annual cost. If only secondary treatment is to be provided for all sewage, the present system in the East Fort Trinity Watershed has total annual costs lower than those of any other alternative, and no increase in the number of contributors would be economically justified. In the West Fork Trinity Watershed,

TABLE IX-1. SENSITIVITY OF COST COMPARISONS

Degree of Treatment	SECONDARY			TERTIARY				
Interest Rate (30-Year Bonds)		6 1/2%			6 1/2%		7 1/2%	5 1/2%
Design Year for Treatment Plants and Pumping Stations	1990	1990	2020	1990	1990	2020	1990	1990
Design Year for Interceptors and Force Mains	2020	1990	2020	2020	1990	2020	2020	2020
	AVERAGE ANNUAL COSTS(1) ($1,000 per Year)							
East Fork Trinity - Watershed 3								
A. Present System	$5,790	$5,650	$8,200	$11,220	$11,080	$16,240	$11,640	$10,800
B. Lake Hubbard System	6,410	5,930	8,550	10,950	10,470	15,250	11,410	10,510
C. East Fork System(2)	6,230	5,690	8,040	10,230	9,670	13,800	10,650	9,800
D. Trinity River System(3)	8,710	7,690	10,430	12,750	11,730	16,210	13,370	12,140
West Fork Trinity - Watershed 5								
A. Present System	8,290			16,690			17,280	16,100
B. Village Creek System(2)	8,000			15,440			16,000	14,880
C. Consolidated System	10,380			17,370			18,300	16,890

(1) Includes amortized capital cost, land, operation, and maintenance. In this table, it is assumed that no existing plants are utilized.
(2) Recommended alternative.
(3) Excludes costs allocated to other watersheds.

TABLE IX-2. COST COMPARISONS FOR UTILIZATION OF EXISTING TREATMENT PLANTS

EAST FORK TRINITY RIVER - WATERSHED 3

	ESTIMATED COSTS OF ALTERNATIVE SYSTEMS							
	Present System		Lake Hubbard		East Fork(4)		Trinity River(2)	
Disposition of Existing Plants(1)	"1"	"2"	"3"	"2"	"3"	"2"	"3"	"2"
CAPITAL COSTS ($1,000)								
Construction of Sewage Treatment Plants								
1. Secondary Treatment Facilities	$34,240	$44,940	$27,660	$33,850	$23,990	$27,110	$25,720	$26,820
2. Additional Tertiary Treatment Facilities	26,460	26,460	19,930	19,930	15,970	15,970	15,960	15,960
3. Land	410	520	510	590	580	640	140	140
Subtotal	$61,110	$71,920	$48,100	$54,370	$40,540	$43,720	$41,820	$42,920
Construction of Interceptors, Pumping Stations, and Force Mains	$12,780	$12,780	$35,150	$35,150	$41,850	$41,850	$79,840	$79,840
Total	$73,890	$84,700	$83,250	$89,520	$82,380	$85,580	$121,660	$122,760
AVERAGE ANNUAL COSTS ($1,000/Year)								
Amortization (30 years at 6-1/2%)	$4,860	$5,570	$5,490	$5,900	$5,410	$5,640	$8,000	$8,050
Operation and Maintenance(3)	5,650	5,650	5,060	5,060	4,590	4,590	4,700	4,700
Total	$10,510	$11,220	$10,550	$10,960	$10,000	$10,230	$12,700	$12,750

Note:

(1) Disposition:

"1" Denotes utilization of all existing plants.
"2" Denotes utilization of no existing plants.
"3" Denotes utilization of existing plants at sites not served by the joint systems.

(2) Excludes costs allocated to other watersheds.
(3) Costs for all facilities.
(4) Recommended alternative shown boxed.

the present system has total annual costs only four percent greater than those of the recommended alternative, if secondary treatment only is provided. However, if advanced treatment is provided as recommended in this report, it would become more advantageous to construct more extensive joint sewerage systems. In the East Fork, alternative C has total annual costs eleven percent less than those of the present system; in the West Fork, Alternative B has total annual costs eight percent less than those of the present system. (On the other hand, the results for both watersheds also indicate that even for advanced treatment, it would be uneconomical to construct joint treatment plants serving entire watersheds.)

Interest Rates on Construction Bonds. The tight money market and inflation of the present time (1970), which have contributed to the current interest rate on municipal bonds of about 6 1/2 percent, cannot be expected to remain unchanged over the long-range planning period to 1990 or 2020. For this reason, interest rates of 5-1/2 percent and 7-1/2 percent have been compared with the 6-1/2 percent rate on the basis of tertiary treatment, to determine if the change in amortized construction cost,compared to the cost of operation and maintenance, is large enough to influence the selection of a sewerage system. The results shown in Table IX-1 indicate that changes in the interest rate would not affect the selection of alternatives studied on the basis of total annual costs.

*Design Periods for Conveyance and Treatment Facilities.*Since the cost of conveyance facilities relative to the cost of treatment plants determines in large measure the feasible extent of consolidation variations in the design period for each type of facility must be considered. For the East Fork Watershed, three combinations of design periods have been examined:

(a) Treatment plants and pumping stations designed for full utilization at the end of the period 1975 to 1990; interceptors and force mains designed for the end of the period 1975 to 2020.

(b) All facilities designed for the end of the period 1975 to 1990.

(c) All facilities designed for the end of the period of 1975 to 2020.

The cost comparisons in Table IX-1 indicate that when gravity interceptors and force mains are designed for the year 1990 rather than 2020, the total annual cost is reduced slightly. However, the considerable costs and associated difficulties of constructing relief interceptors and relief force mains which would then be required in 1990 for 2020 flows more than offset this small, short-term saving. Therefore, it is recommended that interceptors and force mains be designed for the year 2020.

A comparison between the design years 1990 and 2020 for advanced wastewater treatment plants and pumping stations provides an indication of the long-term effects associated with each alternative. In the East Fork Watershed, comparison of Alternative C with the present system (Alternative A), indicates that over the period from 1975 to 1990 Alternative C would provide an average annual savings of about 10 percent while over the long-term period from 1975 to 2020 the savings would increase to approximately 15 percent. These percentage savings cannot be assured, but they do indicate that savings resulting from increased consolidation will tend to increase over a longer time span.

Utilization of Existing Treatment Plants. The adequacy and condition of the existing treatment plants within the study area are discussed in Chapter VIII. For the purposes of the present discussion, two extremes are considered for the East Fork Watershed: phasing out and replacement of existing facilities at all treatment plants before the year 1990; and continued utilization, with expansion if necessary, of certain existing plants which would remain separate in the alternative sewerage system under consideration. A cost comparison of the two extremes, as presented in Table IX-2, indicates that the existing plants in the East Fork are of insufficient size to influence the ranking of the alternatives on the basis of cost. However, the cost difference between utilization and phasing out of existing plants for any specific alternative is of sufficient magnitude to indicate that existing treatment capacity should continue to be utilized whenever possible.

Federal and State Financial Assistance. Under the existing Federal aid program, up to 33 percent of the construction cost is granted for eligible treatment plants, interceptors, pumping stations, and force mains as discussed in Chapter XII. If authorized State grants of at least 25 percent were appropriated, only 25 percent of the total construction cost would be paid locally. Furthermore, if an eligible construction project is consistent with regional planning State and Federal assistance could amount to 80 percent of the construction cost leaving 20 percent to be paid locally.

Construction grants from the Federal Government and matching grants from the State of Texas could affect the selection of a joint treatment system, if only the remaining costs paid locally by the taxpayers of the region are considered. In this case, the costs of operation and maintenance become more significant relative to construction costs, and this tends to favor consolidation of treatment facilities.

For the East Fork Trinity Watershed, the estimated total capital cost for construction of each alternative is contained in Table IX-2. For various levels of Federal and State financial assistance, the remaining total annual cost to be paid locally for each alternative is indicated in Table IX-3.

These results indicate that Alternative D would compare more favorably with the other alternatives at high levels of financial assistance, but would still cost more than Alternative C (the recommended system). For 80 percent assistance, local costs are reduced 30 to 40 percent from those applicable to 30 percent Federal assistance.

In our opinion, the total cost of alternative systems should be employed in the selection, without regard to the allocation of costs between local, State and Federal sources.

GENERAL EFFECTS OF CONSOLIDATION

As emphasized throughout this report, the cost estimates for alternative sewerage systems have been obtained from generalized cost curves. Furthermore, the estimates of future conditions and topographic data should be considered as approximations only and not considered as firmly reliable information. Thus, deviations from cost estimates on the basis of future detailed studies on the order of 10 to 20 percent would not be unexpected.

TABLE IX-3. LOCAL COSTS AFTER FEDERAL AND STATE ASSISTANCE

Federal and State Assistance	ESTIMATED TOTAL ANNUAL COSTS (1) ($1,000/YEAR)			
	A	B	C	D
	Present System	Lake Hubbard	East Fork (2)	Trinity River
0	$11,220	$10,950	$10,230	$12,750
30% (3)	9,550	9,190	8,530	10,400
60%	7,880	7,410	6,840	7,960
80%	6,770	6,230	5,720	6,330

Notes:

(1) Including average amortization, operation, and maintenance of alternative East Fork Trinity systems, with no utilization of existing plants.

(2) Recommended Alternative, shown boxed.

(3) May be 33 percent if project complies with regional planning.

For these reasons, the rationale for selection of recommended alternatives requires cognizance of additional considerations, other than cost, particularly when the estimated cost difference between two alternatives is small compared to the expected deviation in cost. Both advantages and disadvantages must be thoroughly considered. In general, the considerations presented below are concerned with the effectiveness of a pollution control program and with financial effects for which no meaningful cost estimates can be made.

Advantages of Consolidation. In choosing between two alternative sewerage sytems which have approximately the same total cost, selecting the alternative with the higher degree of consolidation would provide the following advantages:

Operation and maintenance. A consistently high quality of operation is more readily obtained in larger treatment plants, due primarily to the larger number of better qualified, more specialized, and more-highly paid personnel required to operate the plant. The present shortage of experienced and qualified personnel provides an impetus toward consolidation of treatment facilities. In addition, a greater degree of automation can be justified as well as centralized, efficient maintenance facilities.

Water reuse. As discussed in Chapter XI an attractive possibility for wastewater reuse in the study area is in the supply of cooling-tower make-up water for thermal electric power plants. Power plants located near large sewage treatment plants would be assured of a high-quality, low-cost, and dependable source of industrial water supply, and the revenues obtained from selling the treatment plant effluent would partially subsidize the cost of treatment.

Flexibility. Future trends in population growth and distribution, and in land use, can be predicted more accurately for the entire service area of a joint sewerage system than for the smaller component population centers. Thus, it is expected that a joint sewerage system should be more adaptable to the actual future growth both in the expected service area and in adjacent areas which potentially may contribute to the system.

Local collection systems. Due to the economy of size of interceptors, a joint sewerage system provides the possibility of cost savings in portions of local collection systems. In addition, isolated sources of pollution along the joint interceptors can be diverted to the joint treatment plant. The considerable intangible advantage of joint collection systems over separate systems is the presence of an interceptor through portions of a service area into which future development may discharge.

Existing plants. Many smaller treatment plants now serving individual communities or groups of communities could be phased out. Most of these plants do not meet present water quality requirements. Phasing out would relieve these communities of responsibility for sewage treatment and would make available trained personnel to operate joint facilities.

Treatment processes. The additional cost for new types of treatment required to meet present and future effluent or stream quality standards, would be less for consolidated facilities due to economy of size. Furthermore, changes in treatment processes deemed desirable in the light of future technical innovations could be accomplished more readily and at less expense in a single joint plant than in several smaller separate plants.

Equitable apportionment of costs. In the absence of a joint system, the cost per capita for sewage treatment can vary widely from one local plant to another, depending upon the size of each plant and the rate of population growth for the corresponding service area. Individual rapidly-growing population centers often find it difficult to pay the high initial per capita costs required for long-term savings in construction. Since all the people, potentially at least, share equal benefits from pollution control, it can be argued that the cost per capita for sewage treatment should be roughly the same for all the people within a watershed; this objective can be approached most effectively by joint participation in a sewerage system. This subject is discussed further in Chapter XII.

Disadvantages of Consolidation. Selection of a joint sewerage system instead of separate treatment plants could have the following disadvantages:

Local benefits. Potential aesthetic, recreational, and industrial benefits to be gained from the availability of highly treated sewage effluent may be less for participating communities located remotely from the joint treatment plant.

Self-purification of streams. If sufficient and natural stream flow or low flow augmentation could be assured, it is conceivable that the need for a joint plant providing advanced treatment (high BOD removal) could be met by distributing several smaller secondary treatment plants along a stream, as is presently the case thus utilizing the natural assimilative capacity of the stream to remove BOD in the reaches between treatment plants. Requirements for low flow augmentation are discussed in Chapter X. However, nutrients would not be removed by secondary plants, and in the study area, the stream flows during the dry periods of the year will probably continue to consist primarily of treatment plant effluent (given the high cost of water for augmentation). For this reason, tertiary treatment appears to be a general requirement.

Water supply. Diversion of the sewage from a community out of a reservoir watershed or to a treatment plant downstream from a reservoir would decrease the safe yield of the reservoir, if the water supply for the community is obtained from the watershed. Presumably, the sewage effluent would be available for reuse at less expense if the effluent were discharged into the reservoir. For example, in the East Fork Watershed, under the recommended system, about 33.8 mgd of

plant effluent in 1990 would be diverted to the Garland-Duck Creek Plant from the watersheds of Lake Lavon and Lake Ray Hubbard reservoirs. This would lower the safe yield of the two reservoirs from an estimated 153.5 mgd to about 120 mgd. Fortunately, in this case, the plant would be located immediately downstream from the Lake Ray Hubbard dam site, such that the effluent would be available for pumping into the reservoir.

Phasing out of Existing Plants. The phasing out of existing treatment plants resulting from consolidation could leave a community with an outstanding debt for which it would receive no return.

COMMUNITIES TO BE SERVED

In this report consolidation is recommended as far as that geographical limit in each watershed at which the economy of large size is just balanced by the diseconomy of long-distance conveyance of sewage. While there may be a large cost advantage to a small community situated at the recommended limit of joint service there may be little or no difference in total joint system cost whether it builds and operates a separate local treatment plant or participates in the joint system.

Tables in this chapter entitled, "Participation in Alternative Sewerage Systems" state explicitly which communities are to be served by separate local treatment plants and which are to be served by the joint systems under the various alternative systems considered. It should be emphasized, however, that the geographical limits of the service areas of the recommended joint systems should be considered indistinct, and that small variances from the anticipated extent of consolidation based on factors not explicitly considered in this study may therefore be made without significantly altering the total estimated costs. Major variances which might result from an unexpectedly large increase in population as from a major development are difficult to predict, and when such an event occurs, adjustments in sewerage requirements may significantly affect projected costs.

COMPARISON OF ALTERNATIVES

GENERAL

The collection of sewage in the study area generally is accomplished by gravity-flow interceptor. Therefore, the sewerage systems considered in this study are separated roughly by the drainage divides between watersheds, and the following discussion of alternatives is divided into separate presentations for each watershed. Tables showing projected populations, flows and loads for the populated areas within each of the twelve watersheds is contained in Chapter V. Each populated area is considered in the discussion of the corresponding watershed, with the following exceptions:

1. **Trinity River - Watershed 1. The White Rock Creek portion of Plano and the Seagoville Federal Correctional Institution are discussed with the East Fork Trinity River - Watershed 3.**

2. West Fork Trinity River-Watershed 5. The portion of the watershed downstream from the existing Village Creek Treatment Plant is included in the discussion of the Elm Fork Trinity River-Watershed 4. This area includes Grand Prairie, Euless, portions of Arlington, and other present or potential contributors to the existing TRA Central Treatment Plant.

As stated previously only limited consideration is given in this study to the costs or other characteristics of the local sewage collection systems required to deliver sewage to an existing or potential treatment plant site. The focus of this study is on the question as to which plant sites should be phased out or not developed, and the flows diverted to joint treatment plants. As far as possible, the emphasis is upon the costs associated with treatment plants and joint conveyance facilities. Exceptions to this criterion are considered only in cases where existing local sewers can be utilized as trunk or intercepting sewers in joint sewerage systems.

In the cost comparisons of alternatives presented in this section, estimated construction costs for advanced treatment facilities of sufficient capacity for the estimated sewage flows in the year 1990, and the cost of operation and maintenance are based on the estimated average flows over the period from 1975 to 1990. Estimated costs for a particular alternative are presented as total costs including both the separate and joint treatment plants within a watershed or service area; two cost estimates are given corresponding with two assumed conditions regarding disposition of existing treatment plants. A first assumption, utilization of existing capacity, implies that present facilities will still be operable until 1990, and will be fully compatible and integrated with expansions to the plant. Since this condition is difficult to assertain without detailed design considerations, a second cost estimate is given, based on the assumption that the existing treatment facilities will be phased out and entirely new facilities constructed at the same site.

Interceptors and force mains have been sized to carry the expected flows in the year 2020,with utilization of the capacity of existing lines. Pumping station equipment has been sized for the expected 1990 flows.

A detailed description of the recommended alternative for each joint system is presented in Chapter X, including the stage of construction. In the comparison of alternatives, the staging of construction has been purposely ignored. The costs and flows to the joint plants presented in this chapter correspond with the assumption that all participants in a joint system would be served by the joint plant before 1990. The small apparent discrepancies between figures presented in Chapters IX and X are the result of the populated areas which would not be served by a recommended joint system until after 1990. Chapter X figures should be considered as governing.

In additon, it should be emphasized that the computerized mathematical model described in the first portion of this chapter has been applied only as an engineering tool in the analysis of alternatives for the study area. Minimum-cost solutions obtained by computer analysis have been employed primarily as an aid to engineering

judgment in the selection of a recommended system. Additional factors considered include protection of water quality, location, capacity and condition of existing facilities, site area available, current planning underway, construction problems and future development. Consideration of such factors indicates that the recommended systems are the most feasible and economical solutions to the pollution control problem in the study area.

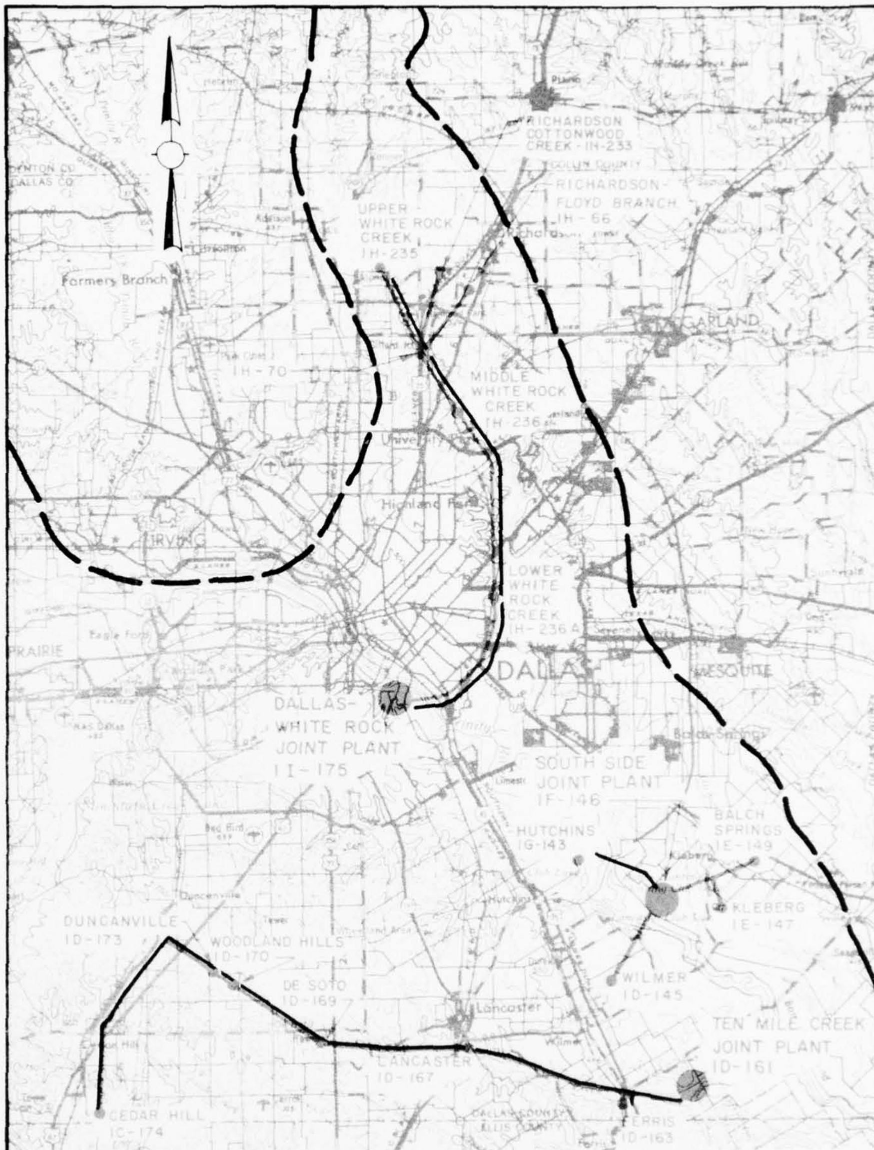
TRINITY RIVER - WATERSHED 1

The Trinity River-Watershed 1, as defined on Fig. V-1 contains three existing joint systems which are associated with the Dallas-White Rock Plant, the Dallas South Side Plant , and the TRA Ten Mile Creek Plant as shown on Fig. IX-2. The Dallas and White Rock Treatment Plants, which share the same site, are considered to be a single plant for the purposes of this discussion. The population centers within the areas served by each of the three existing systems are indicated in Table IX-4. Additional populated areas (which lie outside the three areas served) are also included in Table IX-4 under the designation "Southeastern Area." Each of the four sections of the watershed are discussed separately below. Plans of the alternative joint sewage systems for three sections of Watershed 1 are shown on Fig. IX-2.

Plano (White Rock Creek) and the Seagoville Federal Correctional Institute, which lie within the Trinity River Watershed, are considered as participants in the East Fork system, (Watershed 3) and therefore are not shown in Table IX-4. Although Plano (White Rock Creek) is a potential contributor to the Dallas-White Rock Plant, construction of an interceptor through the heavily built up area along White Rock Lake to serve Plano would be difficult and expensive. Therefore, it is proposed that the Plano portion of the White Rock Creek area be diverted into the East Fork System (Watershed 3). In the case of the Seagoville Federal Correctional Institute, Forrest and Cotton, Inc., is currently conducting a detailed engineering study of sewerage for the Institute. That study indicates it would be economical to pump the flow through a half-mile long force main and into the local collection system of Seagoville, which lies in the East Fork Watershed.

Dallas-White Rock Service Area. As discussed in Chapter II, consideration of the costs and means of reinforcement for city collection systems is not included in the scope of study for this report. Therefore, sewage flows from the following populated areas are considered as local inflows to the Dallas-White Rock Plant: the Dallas Plant area, Coombs Creek, Fair Park area, and the Procter & Gamble factory. Flows from the Elam Creek and Five Mile Creek areas, which are presently treated at the White Rock Plant, are expected to be diverted to the Dallas South Side Plant in the near future (between 1973 and 1980), according to plans adopted by the City of Dallas. Therefore, the flows from these two areas are considered as local inflows to the South Side Plant.

Two principal alternative sewerage systems have been considered as indicated in the cost comparisons of Table IX-5. Under Alternative A (present system) the remaining flows tributary to the White Rock Plant (after diversion of flows from the Elam Creek and Five Mile Creek areas) will be from the White Rock Creek area, which has been divided into three subareas (designated as lower, upper and middle) as indicated in Table IX-4. Although the flows from Richardson (Cottonwood Creek) are now treated at the Dallas-White Rock Plant, these flows could be directed to the Richardson-Floyd Branch Plant if the City of Richardson should decide to remain separate from



LEGEND

WATERSHED BOUNDARY

EXISTING INTERCEPTOR (ALSO ALTERNATIVE A)

ALTERNATIVE B (RECOMMENDED)

NODE ON INTERCEPTOR, OR SEPARATE LOCAL SEWAGE TREATMENT PLANT

JOINT SEWAGE TREATMENT PLANT

5 0 5

SCALE IN MILES

NOTE

PARTICIPATION OF ALL S.T.P.'S IN ALTERNATIVE SYSTEMS IS SHOWN IN TABLE IX.

FIG. IX-2 ALTERNATIVE SEWERAGE SYSTEMS (TRINITY RIVER-WATERSHED I)

JULY, 1970

TABLE IX-4. PARTICIPATION IN ALTERNATIVE SEWERAGE SYSTEMS

TRINITY RIVER - WATERSHED 1

Node No.	Populated Area	1990(1) Average Flow (mgd)	Alternative Sy A	
DALLAS - WHITE ROCK AREA			Present	Cons
1H-66	Richardson - Floyd Branch	2.11	S(3)	
1H-236A	Lower White Rock Creek	27.65	J	
1H-235	Upper White Rock Creek	5.67	J	
1H-236	Middle White Rock Creek	8.71	J	
1H-70	Richardson (Cottonwood Creek)	4.53	S	
1H-175	Dallas Plant Area, Coombs Creek, Fair Park, Procter & Gamble, Inc.	91.04	J	
	Subtotal	139.71		
	Flow(5) to Joint Plant in 1990 (mgd)		133.07	1
DALLAS - SOUTH SIDE AREA			Present	Cons
1D-145	Wilmer	1.14	S	
1F-146	Prairie Creek, Elam Creek, Five Mile Creek	37.71	J	
1E-147	Kleberg	1.66	S	
1E-149	Balch Springs	2.10	S	
1G-143	Hutchins	0.57	J	
	Subtotal	43.18		
	Flow(5) to Joint Plant in 1990 (mgd)		38.28	
TEN MILE CREEK AREA			Separate	Cons
1C-174	Cedar Hill	2.48	S	
1D-163	Ferris	0.33	J	
1D-167	Lancaster	4.15	J	
1D-169	DeSoto	4.09	S	
1D-170	Woodland Hills	0.32	S	
1D-173	Duncanville	5.08	S	
	Subtotal	16.45		
	Flow(5) to Joint Plant in 1990 (mgd)		4.48	
SOUTHEASTERN AREA			Separate	
1B-92	Sonoma	0.11	S	
1C-91	Palmer	0.15	S	
1C-91E	Lower Red Oak Creek	1.41	S	
1C-91	Middle Red Oak Creek	0.41	S	
1D-167A	Upper Red Oak Creek	0.68	S	
	Subtotal	2.76		
	Total Flow	202.10		

Notes:
(1) Flows from populated areas not listed are included in the flo
(2) Recommended alternative.
(3) "S" Denotes separate participation.
"J" Denotes joint participation.
(5) Includes flow from all tributary areas regardless of staging. See Chapter X for flow based on recommended staging. It is r that the City of Dallas is currently considering the diversio 10% more flow from the Dallas - White Rock Plant to the Dalla Side Plant.

TABLE IX-5. COST COMPARISONS OF ALTERNATIVE SYSTEMS

TRINITY RIVER - WATERSHED 1

DALLAS - WHITE ROCK SERVICE AREA

	ESTIMATED COSTS OF ALTERNATIVE SYSTEMS			
	A		B	
	Present		Consolidated	
Disposition of Existing Plants	"1"	"2"	"3"	"2"
CAPITAL COSTS ($1,000)				
Construction of Sewage Treatment Plants:				
1. Secondary Treatment Facilities	$18,230	$36,380	$16,810 (4)	$33,960
2. Additional Tertiary Treatment Facilities	21,430	21,430	20,000	20,000
3. Land	390	950	390	930
Subtotal	$40,050	$58,760	$37,200	$54,890
Construction of Interceptors	7,020	7,020	8,690	8,690
Total	$47,070	$65,780	$45,890	$63,580
AVERAGE ANNUAL COSTS ($1,000/Year)				
Amortization (30 years at 6 1/2%)	$3,080	$4,320	$3,010	$4,190
Operation and Maintenance	7,230	7,230	7,000	7,000
Total	$10,310	$11,550	$10,010	$11,190

Notes:

the Dallas system. This situation is assumed under Alternative A, wh
entail construction of the following facilities:

(a) About 89,000 l.f. (16.8 mi) of relief interceptor along the White Rock trunk sewer.

(b) Expansion of the present 90 mgd Dallas-White Rock Tr Plant to a capacity of about 133 mgd (95 percent of the estimat 1990 flow in the service area), and construction of advanced wa treatment facilities.

(c) Expansion of the present 1.5 mgd Richardson-Floyd Treatment Plant to a capacity of 6.6 mgd and provision of a treatment.

Under Alternative B, the Richardson-Floyd Branch Plant would be the flows from the Floyd Branch and Cottonwood Creek portions of Ri be conveyed to the Dallas-White Rock Plant. Flows from the White area between Loop 12 and the county line would be picked up. The fol would be constructed under Alternative B:

(a) About 119,000 l.f. (22.5 mi) of interceptor.

(b) For the Dallas-White Rock Plant, expansion to a capacity 140 mgd to treat the estimated 1990 sewage flows, and constru advanced treatment facilities.

On the basis of the cost comparison of the two alternatives, A recommended for the Dallas-White Rock Creek service area. Over t 1975 to 1990, the estimated savings under Alternative B would be abou from 1990 to 2020, the relative savings would increase slightly interceptors would not be required until 2020. These savings, while n terms of the whole service area, are however attributable to the ec gained by picking up flows from the Floyd Branch and Cottonwood C Richardson. It is recognized that the Richardson-Floyd Branch plant record of operation and maintenance, and that present sewer rates m for Richardson to remain separate. Nevertheless, Alternative B is re the following reasons:

1. The Richardson-Floyd Branch plant has limited e capability.
2. Alternative B is economically advantageous.
3. Greater flexibility of treatment processes can be achieved plant.
4. Treatment plant effluent will be diverted away from loca and White Rock Lake.

If studies show advanced waste treatment at Richardson to be eco treated effluent would appear warranted. The option of entering a joi still be available at a later date.

Dallas-South Side Service Area. For purposes of the present discussion Elam Creek, Five Mile Creek and Prairie Creek portions of Dallas, Hutchins, are considered to be local inflows to the Dallas-South Side the costs of treatment for these flows are considered. The intercept plans to construct for the Five Mile Creek area would pass within a Hutchins treatment plant, and at relatively small cost the flows from

diverted to the South Side Plant when the Five Mile Creek i
Hutchins sewage treatment plant would then be phased out.

The service area considered for the South Side Plant con
separate treatment plants serving Wilmer, Kleberg, and Balch
Tree WCID #6) as shown on Fig. IX-2. The estimated total co
facilities and plant expansions at these three sites sufficien
flows are listed under Alternative A as included in Table IX-6.
total 1990 flows in the service area would be treated at the
Alternative A if the three plants remain separate. Under th
Side Plant would be expanded to a capacity of about 38 mg
treatment would be provided.

Under Alternative B, the plants serving Wilmer, Kleberg and
phased out and the sewage flows would be conveyed to the D
the case of Wilmer, preliminary investigations indicated
economical to convey the flows to the South Side Plant, as pro
existing TRA Ten Mile Creek Plant. Alternative B would in
following:

(a) About 26,000 l.f. (4.9 mi) of interceptor.

(b) One lift station, one pumping station, and about
main.

(c) Expansion of the existing 7.0 mgd Dallas South
capacity of about 43 mgd by 1990, and construct
treatment facilities.

Alternative B is recommended for the Dallas South Side serv
reasons:

1. The Wilmer, Kleberg and Balch Spring, pla
expansion capability.

2. It is economically advantageous to phase out t
plants and divert their flows to the South Side Plant.

3. A greater degree and flexibility treatment can b
South Side Plant to achieve desired water quality.

4. Treatment plant effluents will be diverted away
streams.

Ten Mile Creek Service Area. Within this service area TRA is
joint sewerage system consisting of interceptors and a 7.0 m
plant to serve the Cities of Ferris, Lancaster, DeSoto, Woo
and Cedar Hill. For this discussion this system is considered t

AD-A036 540 CAMP DRESSER AND MCKEE BOSTON MASS F/G 13/2

UPPER TRINITY RIVER BASIN COMPREHENSIVE SEWERAGE PLAN. VOLUME I--ETC(U)

JUL 70

UNCLASSIFIED NL

3 OF 5

AD
A036540

TABLE IX-6. COST COMPARISONS OF ALTERNATIVE SYSTEMS

TRINITY RIVER - WATERSHED 1

DALLAS - SOUTH SIDE SERVICE AREA

	ESTIMATED COSTS OF ALTERNATIVE SYSTEMS			
	A		B	
	Present		Consolidated	
Disposition of Existing Plants (1)	"1"	"2"	"3"	"2"
CAPITAL COSTS ($1,000)				
Construction of Sewage Treatment Plants:			(4)	
1. Secondary Treatment Facilities	$14,320	$16,960	$12,460	$14,330
2. Additional Tertiary Treatment Facilities	9,990	9,990	8,430	8,430
3. Land	270	330	270	32[illegible]
Subtotal	$24,580	$27,280	$21,160	$23,08[illegible]
Construction of Interceptors, Pumping Stations, and Force Mains	0	0	2,000	2,000
Total	$24,580	$27,280	$23,160	$25,080
AVERAGE ANNUAL COSTS ($1,000/Year)				
Amortization (30 years at 6 1/2%)	$1,610	$1,800	$1,520	$1,650
Operation and Maintenance (3)	2,620	2,620	2,430	2,430
Total	$4,230	$4,420	$3,950	$4,080

Notes:
(1) Disposition: "1" Denotes utilization of all existing plants.
"2" Denotes no utilization of all existing plants.
"3" Denotes utilization of existing plants at sites not served by the joint systems.
(2) Excludes costs allocated to other watersheds.
(3) Costs for all facilities.
(4) Recommended alternative, shown boxed.

In preliminary investigations, Midlothian (in the West Fork Trinity River Watershed 5), Palmer, and the Lower, Middle and Upper Red Oak Creek areas were considered as additional contributors to the Ten Mile Creek system. In terms of total annual costs within this extended service area serving these additional areas, the existing system, with separate local plants for each of the additional contributors, would be about 5 percent less expensive than construction of one consolidated joint sewerage sytem to serve the extended service area. Therefore the extended service area joint system was not given further consideration.

Generalized cost estimates indicate that a small savings (between 1 and 5 percent) would result if the existing system were split up into two joint systems, and Duncanville and Cedar Hill were served by separate local plants. Under this scheme, designated as Alternative A in Table IX-7, Lancaster and Ferris would contribute to the Ten Mile Creek Plant and Woodland Hills would contribute to the plant at DeSoto. Alternative A would involve construction of the following facilities:

(a) About 42,500 l.f. (8.1 mi.) of relief interceptor along portions of the existing Ten Mile Creek interceptor.

(b) Construction of advanced treatment capacity of about 4.5 mgd for the estimated 1990 flows for the TRA-Ten Mile Creek Plant. Secondary treatment facilities now under construction would be adequate.

(c) Expansion and/or construction of advanced treatment plants at DeSoto, Duncanville, and Cedar Hill to capacities of 4.4, 5.1 and 2.5 mgd respectively.

The consolidated existing joint system, Alternative B, would require the following facilities:

(a) About 129,000 l.f. (24.5 mi) of relief interceptor.

(b) Additional pump capacity in one pumping station and about 13,000 l.f. (2.5 mi) of relief force main.

(c) Expansion of the existing 7.0 mgd Ten Mile Creek Plant to a capacity of about 16.5 mgd for the 1990 flows and construction of advanced treatment facilities.

Alternative B is recommended for the Ten Mile Creek Service Area for the following reasons:

1. A joint sewerage system is now under construction and cost comparisons indicate no significant savings would result from separation.

2. The Ten Mile Creek Treatment plant has ample expansion capability, and considerable land area is available at the plant site.

TABLE IX-7. COST COMPARISONS OF ALTERNATIVE SYSTEMS

TRINITY RIVER - WATERSHED 1

TEN MILE CREEK SERVICE AREA

	ESTIMATED COSTS OF ALTERNATIVE SYSTEMS			
	A		B	
	Separate		Consolidated	
Disposition of Existing Plants(1)	"3"	"2"	"3" (4)	"2"
CAPITAL COSTS ($1,000)				
Construction of Sewage Treatment Plants:				
1. Secondary Treatment Facilities	$6,580	$10,120	$4,700	$7,050
2. Additional Tertiary Treatment Facilities	5,960	5,960	4,150	4,150
3. Land	90	150	80	130
Subtotal	$12,630	$16,230	$8,930	$11,330
Construction of Interceptors, Pumping Stations, and Force Mains	1,480	1,480	9,480	9,480
Total	$14,110	$17,710	$18,410	$20,810
AVERAGE ANNUAL COSTS ($1,000/Year)				
Amortization (30 years at 6 1/2%)	$930	$1,170	$1,210	$1,370
Operation and Maintenance (3)	1,160	1,160	970	970
Total	$2,090	$2,330	$2,180	$2,340

Notes:

(1) Disposition: "1" Denotes utilization of all existing plants.
"2" Denotes no utilization of any existing plants.
"3" Denotes utilization of existing plants at sites not served by the joint systems.

(2) Excludes costs allocated to other watersheds.

(3) Costs for all facilities.

(4) Recommended alternative, shown boxed.

3. A large consolidated joint plant may be expected to provide a consistently higher degree of treatment and permit greater flexibility of treatment processes employed than smaller plants.

4. Treatment plant effluents will be kept out of small local streams.

Southeastern Area. Several schemes (not shown in Table IX-4) were examined to investigate the possibility of including one or more portions of the southeast area in a joint system. However as mentioned in the discussion of the Ten Mile Creek service area, it would appear to be uneconomical to include Palmer and the Red Oak Creek areas in the Ten Mile Creek system. Palmer and Red Oak Creek were also considered as potential contributors to a joint plant near the mouth of the East Fork Trinity River, which would also serve the populated areas of Terrell, Kaufman, and Kemp in the northern portion of the Cedar Creek Watershed. The total average annual cost for such a consolidated system would cost about 53 percent more than the cost for separate treatment plants in each populated area. In addition it did not appear to be economical to carry flows generated within the East Fork Trinity River-Watershed 3 to a plant at the mouth of the East Fork. Furthermore, it did not appear feasible to convey flows from the southeastern area to a possible joint plant at Ennis in Chambers-Waxachachie Creek-Watershed 10.

Based on the above considerations, it is recommended that separate local plants be constructed for the five populated areas at Sonoma, Palmer, and Red Oak Creek within the southeastern portion of the Trinity River Watershed, as shown in Table IX-4. By 1990, a total combined capacity of about 2.8 mgd will be required. The total construction cost for tertiary treatment plants would be about $5,200,000 without utilization of existing capacities of secondary plants, or $4,820,000 utilizing existing capacities of secondary plants at Sonoma and Palmer. The average annual costs of operation and maintenance between 1975 and 1990 are estimated to be $330,000 per year.

CEDAR CREEK-WATERSHED 2

The populated areas served by the ten existing treatment plants in the Cedar Creek Watershed are indicated in Table IX-8. The industrial wastewater flows from Nipak, Inc., have been included in the flows for Trinidad. The City of Terrell is currently planning the construction of a new treatment plant downstream from the two existing plants on Kings Creek as discussed in Chapter IV.

Preliminary investigations indicated the infeasibility of treating the flows from Terrell and Kaufman at a joint plant near the mouth of the East Fork Trinity River. The additional cost to the East Fork participants alone, neglecting the cost of conveyance facilities for Terrell and Kaufman would exceed the costs of separate plants for the two communities (see Alternative D in the discussion of the East Fork Trinity River-Watershed 3).

The possibility of diverting sewage from the populated areas above Cedar Creek Reservoir to a joint treatment plant in Trinidad was also given preliminary consideration. However, the small sewage flows, long distances, and number of pumping stations involved in this scheme indicated that such diversions to protect the reservoir are not feasible within the forseeable future.

TABLE IX-8. PARTICIPATION IN ALTERNATIVE SEWERAGE SYSTEMS

CEDAR CREEK - WATERSHED 2

Node No.	Populated Area	1990 Average Flow (mgd)	Alternative Systems A[1] Present	B Joint Pairs	C Consolidated
2A-202	Mabank	0.16	S[2]	S	S
2A-203	Malakoff	0.29	S	J[2]	J
2A-204	Athens (North)	0.65	S	J	J
2A-205	Athens (West)	1.08	S	J	J
2A-208	Trinidad (Including Nipak, Inc.)	0.55	S	J	J
2B-191	Wills Point	0.28	S	S	S
2C-192	Terrell (Kings Creek)	2.06	S	J	J
2C-193	Terrell (Bachelor Creek)	0.54	S	J	J
2C-196	Kaufman	0.65	S	J	J
2C-199	Kemp	0.11	S	S	J
	Total Flow	6.37			
Estimated 1990 Flow for Joint Participants (mgd)			0	5.82	5.93

Notes:

(1) Recommended Alternative.

(2) "S" Denotes separate participation.

"J" Denotes joint participation.

The three alternatives considered for the Cedar Creek Watershed are described below:

Alternative A (Present System Recommended). The total costs for separate local treatment plants serving the ten populated areas are shown in Table IX-9, under Alternative A. If Terrell plants are consolidated as planned, costs are not expected to be seriously affected.

Alternative B (Joint Pairs System). Under this alternative, three joint plants would be constructed with two contributors to each joint plant, as follows: Terrell and Kaufman; Malakoff and Trinidad; and Athens (North) and Athens (West). The Terrell-Kaufman system would require 65,000 l.f. (12.3 mi) of interceptor and a 3.25 mgd tertiary treatment plant for the estimated 1990 flows.

The Malakoff-Trinidad system would contain 20,600 l.f. (3.9 mi) of interceptor, a pumping station, 2,700 l.f. of force mains, and a tertiary treatment plant to handle 0.84 mgd in 1990. The Athens (West) treatment plant could serve both portions of Athens by constructing 9,000 l.f. of interceptor, one pumping station, 12,500 l.f. of force main, and plant expansion to 1.73 mgd by 1990. Other populated areas would be served by separate local plants.

Alternative C (Consolidated System). This alternative considers the possibility of conveying sewage from Terrell and Kemp to a joint treatment plant at Kaufman; and from Athens and Malakoff to a joint treatment plant at Trinidad. Under Alternative C, the following facilities would be constructed:

1. 65,000 l.f. (12.3 mi) of gravity interceptor to the Kaufman joint treatment plant and 79,000 l.f. (15 mi) of gravity interceptor to the Trinidad joint treatment plant.

2. Two pumping stations and 65,000 l.f. (12.3 mi) of force mains to the Kaufman plant and two pumping stations and 15,000 l.f. (2.9 mi) of force mains to the Trinidad plant.

3. Construction of a treatment plant with a capacity of about 3.4 mgd for estimated 1990 flows in Kaufman and a treatment plant with a capacity of 2.6 mgd in Trinidad.

Selection of the Recommended Plan. The cost comparison of the three alternatives in Table IX-9 indicates that Alternative A (Preliminary System) is the most economical. Thus it does not appear economical to construct any joint system in the Cedar Creek Watershed at the present time.

EAST FORK TRINITY RIVER-WATERSHED 3

Four alternative sewage systems for the East Fork Trinity River (Watershed 3) have been selected for comparison purposes. Plans of the alternative sewerage systems are shown on Fig. IX-3, and the populated areas which would participate in joint collection and treatment facilities for each alternative are indicated in Table IX-10. Existing separate plants serving areas which would participate in joint facilities would

TABLE IX-9. COST COMPARISONS OF ALTERNATIVE SYSTEMS

CEDAR CREEK - WATERSHED 2

	ESTIMATED COSTS OF ALTERNATIVE SYSTEMS					
	A		B		C	
	Present		Joint Pairs		Consolidated	
Disposition of Existing Plants(1)	"1"	"2"	"3"	"2"	"3"	"2"
CAPITAL COSTS ($1,000)						
Construction of Sewage Treatment Plants:						
1. Secondary Treatment Facilities	$3,090(3)	$6,450	$4,490	$5,390	$3,680	$4,000
2. Additional Tertiary Treatment Facilities	3,710	3,800	3,170	3,170	2,360	2,360
3. Land	20	20	20	20	20	20
Subtotal	$6,820	$10,270	$7,680	$8,580	$6,060	$6,380
Construction of Interceptors, Pumping Stations, and Force Mains	0	0	4,300	4,300	9,050	9,050
Total	$6,820	$10,270	$11,980	$12,880	$15,110	$15,430
AVERAGE ANNUAL COSTS ($1,000/Year)						
Amortization (30 years at 6 1/2%)	$450	$680	$790	$850	$1,000	$1,020
Operation and Maintenance(2)	740	740	680	680	670	670
Total	$1,190	$1,420	$1,470	$1,530	$1,670	$1,690

Notes:

(1) Disposition: "1" Denotes utilization of all existing plants.
"2" Denotes no utilization of all existing plants.
"3" Denotes utilization of existing plants at sites not served by the joint systems.

(2) Costs for all facilities.

(3) Recommended alternative, shown boxed.

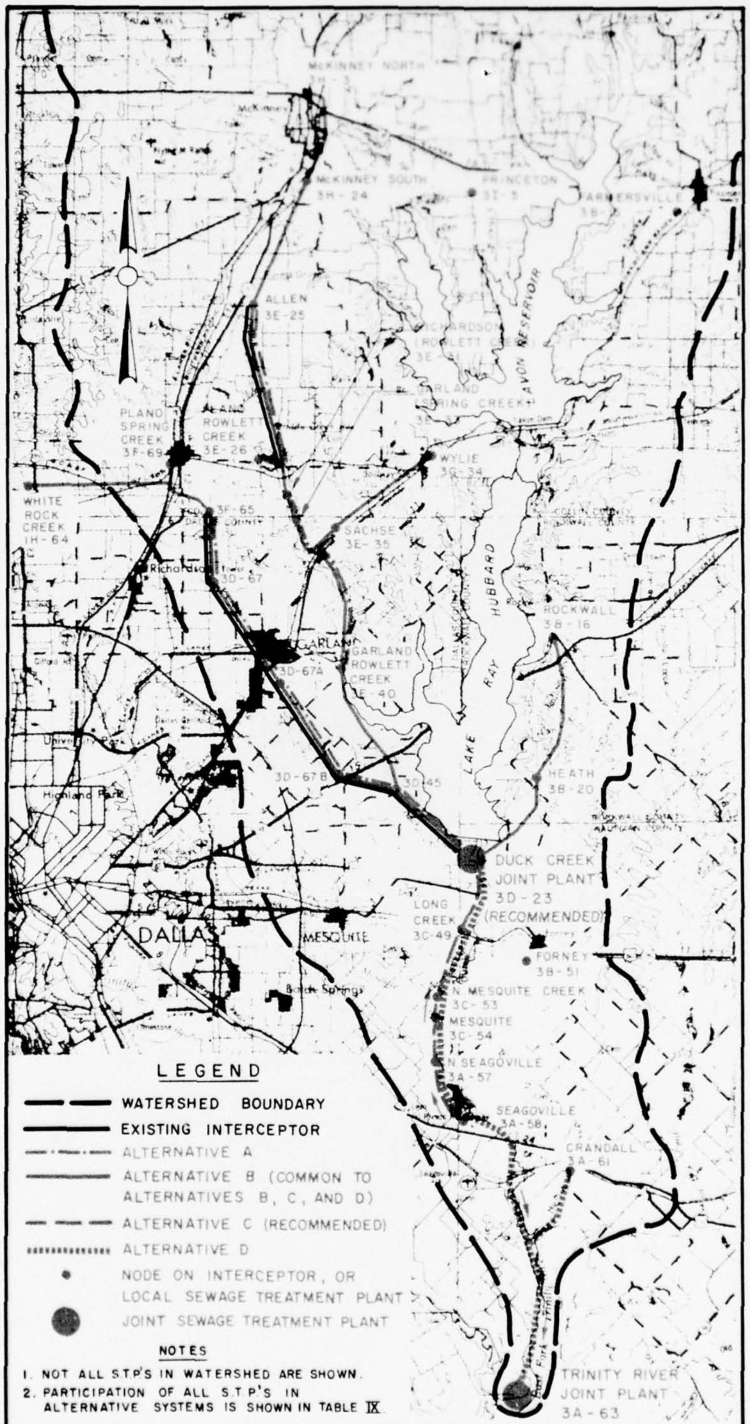


FIG. IX-3 ALTERNATIVE SEWERAGE SYSTEMS (EAST FORK TRINITY - WATERSHED 3)

5 0 5
SCALE IN MILES

JULY, 1970

469-13850

TABLE IX-10. PARTICIPATION IN ALTERNATIVE SEWERAGE SYSTEMS

EAST FORK TRINITY RIVER - WATERSHED 3

Node No.	Populated Area	1990[1] Average Flow (mgd)	Alternative Systems A Expanded Present	B Lake Hubbard	C East Fork[2]	D Trinity River
1H-64	Plano*[3]	3.80	S[4]	J[4]	J	J
3A-57	N. Seagoville	1.20	S	S	J	J
3A-58	Seagoville (Incl. Fed. Corr. Inst.)	1.50	S	S	J	J
3A-61	Crandall	0.12	S	S	S	J
3B-15	Farmersville	0.26	S	S	S	S
3B16	Rockwall	2.50	S	J	J	J
3B-20	Heath	0.54	S	J	J	J
3B-51	Forney	0.32	S	S	S	S
3C-49	Long Creek	0.65	S	S	J	J
3C-53	North Mesquite Creek	2.42	S	S	J	J
3C-54	Mesquite	11.25	S	S	J	J
3D-23	Sunnyvale	4.91	J	J	J	J
3D-45	Garland*(2)	3.82	J	J	J	J
3D-67	Richardson*	1.86	J	J	J	J
3D-67A	Garland*	7.68	J	J	J	J
3D-67B	Garland,* Mesquite*	6.55	J	J	J	J
3E-25	Allen	4.21	J	J	J	J
3E-26	Plano	7.53	J	J	J	J
3E-31	Richardson*	0.88	J	J	J	J
3E-33	Garland*	5.07	J	J	J	J
3E-35	Sachse	1.80	J	J	J	J
3E-40	Rowlett, Garland*	6.67	J	J	J	J
3F-65	Richardson*	2.71	J	J	J	J
3F-69	Plano*	9.79	J	J	J	J
3G-34	Wylie	0.67	S	J	J	J
3H-1	Anna	0.07	S	S	S	S
3H-3	McKinney (North)	0.25	S	J	J	J
3H-24	McKinney (South)	3.65	S	J	J	J
3I-0	Van Alstyne	0.26	S	S	S	S
3I-5	Princeton	0.14	S	S	S	S
3J-7	Tom Bean	0.04	S	S	S	S
3J-8	Blue Ridge	0.04	S	S	S	S
3J-11	Trenton	0.10	S	S	S	S
3J-14	Leonard	0.15	S	S	S	S
	Total Flow	93.41				
Estimated 1990 Flow for Joint Participants (mgd)			63.48	74.89	91.91	92.03[5]

Notes:

(1) Flows from populated areas not listed are included in the flows shown.
(2) Recommended alternative.
(3) * Denotes part of populated area.
(4) "J" Denotes joint participation.
"S" Denotes separate participation.
(5) Excludes 5.88 mgd allocated to other watersheds.

be phased out. Flows from the Seagoville Federal Correctional Institution are included in the flows for Seagoville. Both the existing Garland-Rowlett Creek and Garland-Duck Creek treatment plants are being considered for expansion at the present time. Cost comparisions for the four alternatives are presented in Table IX-2.

Alternative A (Present System). The largest existing sewerage system in the East Fork Watershed is composed of a series of interceptors along Duck Creek and Jupiter Road. By reinforcement and minor extension, this system would serve the following populated areas; Plano (Spring Creek), Richardson (Spring Creek), Richardson (Duck Creek), Garland (Duck Creek), Garland (Lower Rowlett Creek), Mesquite-Dallas (Duck Creek), and Sunnyvale (Duck Creek). Sewage from these areas would be treated at the Garland-Duck Creek Plant located at the mouth of Duck Creek along the East Fork. The participants in the exisiting Garland-Duck Creek system are indicated in Table IX-10 under Alternative A. However, several additional joint systems are included under this alternative, as follows: the Garland-Rowlett plant would serve Sachse and the Rowlett Creek portions of Richardson and Garland; Plano (Rowlett Creek) and Allen would be served by expansion of the existing Plano plant. Sewage from these areas would amount to about 68 percent of the estimated 1990 sewage flow for the watershed.

Facilities constructed for this alternative would include the following:

(a) About 180,000 l.f. (34 mi) of gravity interceptors.

(b) Two pumping stations and about 9,000 l.f. of relief force mains.

(c) Plant expansion of the existing 10 mgd plant to a total capacity of about 37 mgd and advanced treatment facilities by 1990 at the Garland-Duck Creek site.

(d) Expansion and/or construction of 21 additional treatment plants including the Garland-Rowlett Creek Plant) to serve the remaining populated areas in the watershed.

Alternative B (Lake Ray Hubbard System),. Under this alternative, the service area for the Garland- Duck Creek Plant would be increased to handle approximately 80 percent of the total 1990 sewage flow for the watershed, by including the major populated areas north of the plant in the drainage basin of Lake Ray Hubbard. These populated areas would be served by four sewer lines, as follows:

(a) Interceptors and force mains along the eastern shore of Lake Ray Hubbard, serving Rockwall and Heath;

(b) Interceptors and force mains along the Rowlett Creek, serving the populated areas west of Lake Ray Hubbard, including McKinney, Allen, Richardson (Rowlett Creek), Garland (Spring Creek), Garland (Rowlett Creek), and Rowlett;

(c) An interceptor from Plano (Rowlett Creek) to the Rowlett Creek line described above;

(d) A force main and interceptors to carry sewage from Wylie and Sachse to the Rowlett Creek line.

In addition, flows from Plano (White Rock Creek) would be pumped to the upstream end of the existing Duck Creek line. The Rowlett Creek line would contain a pumping station and force main at the downstream end to pump between basins from Rowlett Creek to the existing Duck Creek interceptor. With the exception of McKinney, Rockwall and Heath the participants in this joint system would be the same as those in the system recommended in the preliminary report prepared by I.W. Santry, Inc., for the City of Garland. For Alternative B, the following facilities would be constructed:

(a) About 232,800 l.f. (44 mi) of interceptors:

(b) Eight pumping stations and about 168,000 l.f. (32 mi) of force mains:

(c) Plant expansion from an exisiting capacity of 10 mgd to a capacity of about 75 mgd by 1990 and facilities for advanced treatment at the Garland-Duck Creek joint treatment plant;

(d) Expansion and/or construction of 13 additional treatment plants to serve the remaining populated areas.

Alternative C (East Fork System–Recommended). For this system, interceptors and force mains would be constructed to carry the sewage flows from the areas included in Alternative B, and in addition flow from Mesquite, Seagoville, North Seagoville area, North Mesquite Creek area, and the Long Creek area would be carried upstream along the East Fork Trinity River to the Garland–Duck Creek Plant. This plant would then treat about 98 percent of the estimated total 1990 sewage flow for the watershed.

For Alternative C, the following facilities would be required:

(a) About 259,000 l.f. (49 mi) of gravity interceptors.

(b) Twelve pumping stations and 224,000 l.f. (42.5 mi).

(c) Plant expansion from an existing capacity of 10 mgd to a capacity of about 92 mgd at the Garland–Duck Creek joint treatment plant.

(d) Expansion and/or construction of 10 additional treatment plants to serve the remaining populated area.

Alternative D (Trinity River System). Under this alternative, a joint treatment plant would be constructed near the confluence of the East Fork and the Trinity River, which treat approximately 98 percent of the estimated 1990 sewage flows in the East Fork Watershed. The Trinity River joint plant would be located approximately 19 miles downstream from Mesquite. In addition to the populated areas served by the joint system for Alternative C, Crandall would contribute flows to the Trinity River joint plant. Because the joint plant would be accessible to areas outside the East Fork Watershed, Terrell, Kaufman, and the Red Oak Creek areas have been included as participants, and a portion of the costs for the joint treatment plant have been allocated to these populated areas based on estimated sewage flow.

Facilities required for Alternative D would include the following:

(a) About 380,000 l.f. (72 mi) of gravity interceptors.

(b) Eight pumping stations and about 168,000 l.f. (32 mi) of force mains.

(c) Trinity River joint treatment plant, with a capacity of about 98 mgd (92 mgd allocated to the East Fork Watershed).

(d) Expansion and/or construction of nine additional treatment plants to serve the remaining populated area.

Selection of Recommended System. For the East Fork Trinity River Watershed 3, the East Fork System (Alternative C) utilizing existing plants at sites not served by the joint system is recommended for the following reasons:

1. Under a broad variety of conditions examined in the previous section of this chapter, the recommended system would be less expensive than the other alternatives considered (see Table IX-1, IX-2 and IX-3).

2. The recommended joint system would insure the maintenance of high water quality standards for Lake Ray Hubbard, by conveyance of sewage from the major populated areas in the reservoir watershed to the Garland-Duck Creek Plant downstream from the dam. Also, sewage from isolated sources along the shores would then be picked up by the proposed interceptors. Since the land surrounding Lake Ray Hubbard reservoir is being developed at a rapid pace, and the reservoir is easily accessible to residents of the Dallas metropolitan area, the reservoir is important as a potential recreation area.

3. If necessary at some time in the future, the effluent from the joint treatment plant on Duck Creek could be pumped a short distance upstream into Lake Hubbard and used for water supply after dilution with reservoir water.

4. The Duck Creek plant is currently planned to be expanded and the site has further expansion capabilities.

5. Consolidation of treatment facilities will permit greater flexibility in adjusting treatment processes to meet water quality requirements.

ELM FORK TRINITY RIVER-WATERSHED 4

All present and potential contributors to the existing TRA Central Sewage Treatment Plant, located near the confluence of the West Fork and Elm Fork of the Trinity River are included in the present discussion. The service area considered for this plant comprises the Elm Fork Watershed, and that portion of the West Fork Trinity River-Watershed 5 located downstream from the Village Creek Treatment Plant. The possibility of combining the flows from various large joint treatment plants, such as the Village Creek, TRA Dallas and Duck Creek plants into one mammoth plant is considered at the end of this chapter.

The population centers and their participation in the three alternative sewerage systems considered for this service area are indicated in Table IX-11. Plans for the three alternatives are shown on Fig. IX-4 and cost comparisons are contained in Table IX-12.

Preliminary investigations indicated that it would not be economical, in the foreseeable future, to divert all of the sewage flows (including those from Denton and Gainesville) out of the drainage basins of Garza-Little Elm and Grapevine Reservoirs. At present, the best means for protection of water quality in these reservoirs appears to be the construction and/or expansion of existing plants and the provision of tertiary treatment for sewage from the communities within the reservoir basins.

For the Garza-Little Elm Reservoir basin, a sewerage system serving Denton and other communities on the western side of the reservoir was considered, which would carry sewage to a joint plant at Denton. The total annual cost of this system would be roughly 3 percent higher than the cost of the recommended Alternative B, described below. In this case of the Grapevine Reservoir, the cost of a joint sewerage system would be about twice the cost of separate local treatment plants for the populated areas in the basin. The only community which it appears economical to include in a joint system is Grapevine (see Alternative B).

The three alternative systems selected for comparison after preliminary investigation are described briefly below.

Alternative A (Present System). The present contributors to the existing TRA Central Plant are indicated as joint participants in Alternative A as shown in Table IX-11. For Alternative A, it is assumed that the remaining populated areas would be served by separate treatment plants. By plant expansion and reinforcement of trunk sewers, the existing joint system would receive about 47 percent of the estimated total 1990 sewage flow in the potential service area. Alternative A would require construction of the following facilities:

(a) About 196,000 l.f. (37 mi) of gravity interceptors.

(b) Three pumping stations and about 9,000 l.f. of force mains.

(c) At the site of the existing 30 mgd TRA Central Plant, expansion to a capacity of about 57 mgd by 1990 and provision of advanced treatment.

(d) Construction and/or expansion of approximately 50 additional treatment plants to serve the remaining populated areas.

Alternative B (Partially Consolidated System-Recommended). In the Elm Fork Watershed, a major interceptor serving Coppell and Lewisville would be constructed along the Elm Fork interceptor. The portion of Grapevine which drains into Grapevine Reservoir would be served by a branch interceptor. This interceptor would carry flows to the Lewisville-Elm Fork interceptor.

Communities beyond Lewisville and Grapevine would be served by separate local treatment plants. Preliminary investigation indicates that to include Denton in the joint sewerage system would be slightly more expensive than to provide Denton with

TABLE IX-11. PARTICIPATION IN ALTERNATIVE SEWERAGE SYSTEMS

ELM FORK TRINITY RIVER - WATERSHED 4[(1)]

Node No.	Populated Area	1990[(2)] Average Flow (mgd)	Alternative Systems A Present	B Partially[(3)] Consolidated	C Fully Consolidated
4A-81	Lewisville	4.09	S[(5)]	J[(5)]	J
4A-112	Grapevine Creek	4.63	J	J	J
4A-114	Hackberry Creek	6.95	J	J	J
4A-117	Carrollton	7.00	J	J	J
4A-120	Farmers Branch	4.63	J	J	J
4A-122	Dallas*[(4)]	0.83	J	J	J
4A-124	Irving*	15.05	J	J	J
4A-163	Coppell	2.51	S	J	J
4B-150	Justin	0.24	S	S	J
4B-151	Roanoke	0.09	S	S	J
4B-156	Grapevine*	3.80	S	J	J
4B-159	Future Development	0.03	S	S	J
4B-161	Future Development	0.03	S	S	J
4C-50	Muenster	0.22	S	S	J
4C-51	Myra	0.02	S	S	J
4C-54	Lindsay	0.04	S	S	J
4C-55	Gainesville	2.32	S	S	J
4C-58	Valley View	0.14	S	S	J
4C-71	Denton	8.17	S	S	J
4C-74	Camp Copass	0.03	S	S	J
4C-76	Shady Shores	0.02	S	S	J
4C-70A	Lake Dallas	0.15	S	S	J
4C-206	Prosper	0.05	S	S	J
4C-209	Frisco	0.25	S	S	J
4D-100	Krum	0.09	S	S	J
4D-104	Argyle	0.05	S	S	J
4E-2	Rosston	0.02	S	S	J
4E-3	Leo	0.01	S	S	J
4E-8	Bolivar	0.02	S	S	J
4E-10	Sanger	0.32	S	S	J
4F-60	Pilot Point	0.34	S	S	J
4F-64	Aubrey	0.18	S	S	J
4F-200	Gunter	0.09	S	S	J
4F-204	Celina	0.20	S	S	J
4G-213	Collinsville	0.08	S	S	J
4G-214	Tioga	0.06	S	S	J
5A-19	Regional Airport	5.00	S	J	J
5A-20	Keller	0.75	S	J	J
5A-21	Southlake*	0.54	S	J	J
5A-22	Southlake*	0.54	S	J	J
5A-23	Colleyville*	1.96	S	J	J
5A-24	Grapevine	2.95	S	J	J
5A-30	Irving	1.75	J	J	J
5A-60	Greenview	0.06	J	J	J
5B-25	North Richland Hills	0.44	S	J	J
5B-26	Hurst*	0.63	S	J	J
5B-27	Bedford	0.31	S	J	J
5B-28	Colleyville	0.00	J	J	J
5B-29	Euless*	1.81	J	J	J
5C-1	Venus	0.05	S	S	J
5C-65	Grand Prairie	7.49	J	J	J
5C-208	East Mountain Creek*	0.50	J	J	J
5C-211	East Mountain Creek*	1.46	S	S	J
5C-350	Kirby Creek	6.70	J	J	J
5C-450	Future Development	1.11	S	J	J
5C-451	Future Development	0.70	S	J	J
5C-452	Future Development	3.79	S	J	J
5C-453	Future Development	1.59	S	J	J
5C-500	Midlothian	0.37	S	S	J
5D-214	Mansfield	1.24	S	S	J
5D-448	Future Development	1.38	S	J	J
5D-449	Future Development	1.03	S	J	J
5E-195	Arlington*	14.04	S	J	J
5F-184	Euless*	7.05	S	J	J
5F-186	Arlington*	1.28	S	J	J
5F-188	Euless*	2.26	S	J	J
5F-190	Arlington	1.28	S	J	J
Total 1990 Flows, Both Watersheds		132.81	57.40	116.43	132.81

Notes: (1) Plus part of West Fork Trinity River - Watershed 5.
(2) Flows from populated areas not listed are included in the flows shown.
(3) Recommended alternative.
(4) * Denotes part of populated area.
(5) "J" Denotes joint participation.
"S" Denotes separate participation.

LEGEND

WATERSHED BOUNDARY

EXISTING INTERCEPTORS (ALSO ALTERNATIVE A)

ALTERNATIVE B (RECOMMENDED)

ALTERNATIVE C

NODE ON INTERCEPTOR OR SEPARATE LOCAL SEWAGE TREATMENT PLANT

JOINT SEWAGE TREATMENT PLANT

SCALE IN MILES

NOTES

1. NOT ALL S.T.P.'S IN WATERSHED ARE SHOWN.
2. PARTICIPATION OF ALL S.T.P.S IN ALTERNATIVE SYSTEMS IS SHOWN IN TABLE IX-

FIG. IX-4 ALTERNATIVE SEWERAGE SYSTEMS (ELM FORK, WEST FORK TRINITY TRIBUTARY TO TRA PLANT - WATERSHEDS 4 AND 5)

JULY, 1970

469 - 13851

TABLE IX-12. COST COMPARISONS OF ALTERNATIVE SYSTEMS

ELM FORK TRINITY RIVER - WATERSHED 4

	ESTIMATED COSTS OF ALTERNATIVE SYSTEMS					
	A		B		C	
	Present		Partially Consolidated		Fully Consolidated	
Disposition of Existing Plants(1)	"1"	"2"	"3"	"2"	"4"	"2"
CAPITAL COSTS ($1,000)						
Construction of Sewage Treatment Plants:						
1. Secondary Treatment Facilities	$52,960	$67,420	$30,820(3)	$42,150	$27,110	$32,720
2. Additional Tertiary Treatment Facilities	39,700	39,700	25,370	24,570	19,240	20,240
3. Land	770	1,010	600	800	670	850
Subtotal	$93,430	$108,130	$56,790	$67,520	$47,020	$53,810
Construction of Interceptors, Pumping Stations, and Force Mains	15,570	15,570	56,240	56,240	121,070	121,070
Total	$109,000	$123,700	$113,030	$123,760	$168,090	$174,880
AVERAGE ANNUAL COSTS ($1,000/Year)						
Amortization (30 years at 6 1/2%)	$7,180	$8,150	$7,450	$8,140	$11,100	$11,500
Operation and Maintenance (2)	8,410	8,410	6,400	6,400	6,100	6,100
Total	$15,590	$16,560	$13,850	$14,540	$17,200	$17,600

Notes:

(1) Disposition: "1" Denotes utilization of all existing plants.
"2" Denotes no utilization of existing plants.
"3" Denotes utilization of existing plants at sites not served by the joint systems.
"4" Denotes utilization of existing TRA plant only.

(2) Costs for all facilities.

(3) Recommended alternative, shown boxed.

(4) Includes costs for portions of the West Fork Trinity River - Watershed 5.

separate advanced treatment facilities. Subsequent detailed studies may indicate that sewage should be carried from Denton to the joint system to safeguard the quality of Garza-Little Elm Reservoir. In such a case however, it might be found undesirable to reduce the safe yield of Garza-Little Elm Reservoir through the diversion of sewage treatment plant effluent to a downstream location.

In the portion of the West Fork Watershed below the Village Creek plant, the existing sewerage system would be extended to serve all the populated areas with the exception of Venus, East MountainCreek,Midlothian, and Mansfield. Approximately 86 percent of the estimated total 1990 sewage flows in the potential service area could be conveyed to the site of the existing TRA Central Plant under Alternative B. Facilities constructed would include the following:

(a) About 566,400 l.f. (107 mi.) of gravity interceptors.

(b) Six pumping stations and about 19,000 l.f. (4 mi.) of force mains.

(c) Expansion of the existing 30 mgd TRA Central Plant to a capacity of about 116 mgd by 1990, and construction of advanced treatment facilities.

(d) Expansion and/or construction of about 32 additional treatment plants to serve the remaining populated portions of the service area.

Alternative C(Fully Consolidated System). Under this alternative, all sewage flows in the potential service area would be conveyed to the site of the existing TRA Central Plant. The following facilities would be required:

(a) About 1,920,000 l.f. (364 mi.) of gravity interceptors.

(b) Fifteen pumping stations and about 81,000 l.f. (15.3 mi.) of force mains.

(c) Expansion of the existing 30 mgd TRA plant to a capacity of about 133 mgd, and construction of advanced treatment facilities. All existing separate treatment plants would be phased out.

Selection of Recommended System. The partially consolidated system (Alternative B) utilizing existing plants at sites not served by the joint system is recommended for the following reasons:

1. As indicated by the cost comparisons in Table IX-12, the recommended system would cost less than the present system by approximately 12 percent. It is also less expensive under the conditions presented in Table IX-1.

2. The recommended joint sewerage system would provide the general advantages of consolidation, such as attractive possibilities for wastewater reuse, high quality of operation, and flexibility in treatment processes employed to achieve desired water quality.

3. The existing TRA Central Plant site has capability for future expansion.

4. The recommended alternative system makes optimum economic use of existing treatment plants.

WEST FORK TRINITY RIVER - WATERSHED 5

The following discussion is concerned with the Fort Worth area and other portions of the West Fork Watershed which lie upstream from the existing Village Creek Sewage Treatment Plant. The Village Creek system, together with the Riverside Plant, serves 17 neighboring populated areas in addition to Fort Worth and constitutes a partially consolidated system for the West Fork Watershed. Consideration of the remainder of the watershed, which includes Euless and portions of Arlington and Grand Prairie, is contained in the discussion of the Elm Fork Watershed, since those areas are potential contributors to the TRA Central Treatment Plant.

Table IX-13 contains a list of the populated areas which are potential contributors to the Village Creek plant, and indicates the participation of these areas considered in each of three alternative systems, described below. Plans of the three alternatives are shown in Fig. IX-5 and cost comparisons are presented in Table IX-14.

Alternative A (Present System). Fort Worth and nearby communities are served at present by an extensive sewerage system with treatment provided at the Riverside and Village Creek Treatment Plants. At the Riverside Plant, excess flows overflow or are conveyed to the Village Creek plant for treatment. The decision has recently been made to phase out the Riverside Plant and divert all flows to the Village Creek Plant. Therefore, no consideration is given herein to retaining or expanding the Riverside Plant.

Under Alternative A, only the present contributors would participate in the Village Creek joint sewerage system, and the remaining populated areas in the watershed would be served by separate treatment plants. For this condition, the Village Creek plant would treat about 80 percent of the estimated 1990 total sewage flows for the West Fork Watershed upstream from the plant. Facilities required would include the following:

(a) About 333,000 l.f. (63 mi.) of relief gravity interceptors in the existing joint sewerage system.

(b) One pumping station and about 3,500 l.f. of force main.

(c) Expansionof the 45 mgd Village Creek Plant to a capacity of about 148 mgd by 1990, and provision of advanced treatment facilities.

(d) Expansion and /or construction of about 42 additional treatment plants to serve the remaining populated areas.

Alternative B (Village Creek System-Recommended). Under this alternative, the present joint sewerage system would be relieved and extended to carry about 96 percent of the total estimated sewage flows in 1990. Extensions to the system would serve the following areas:

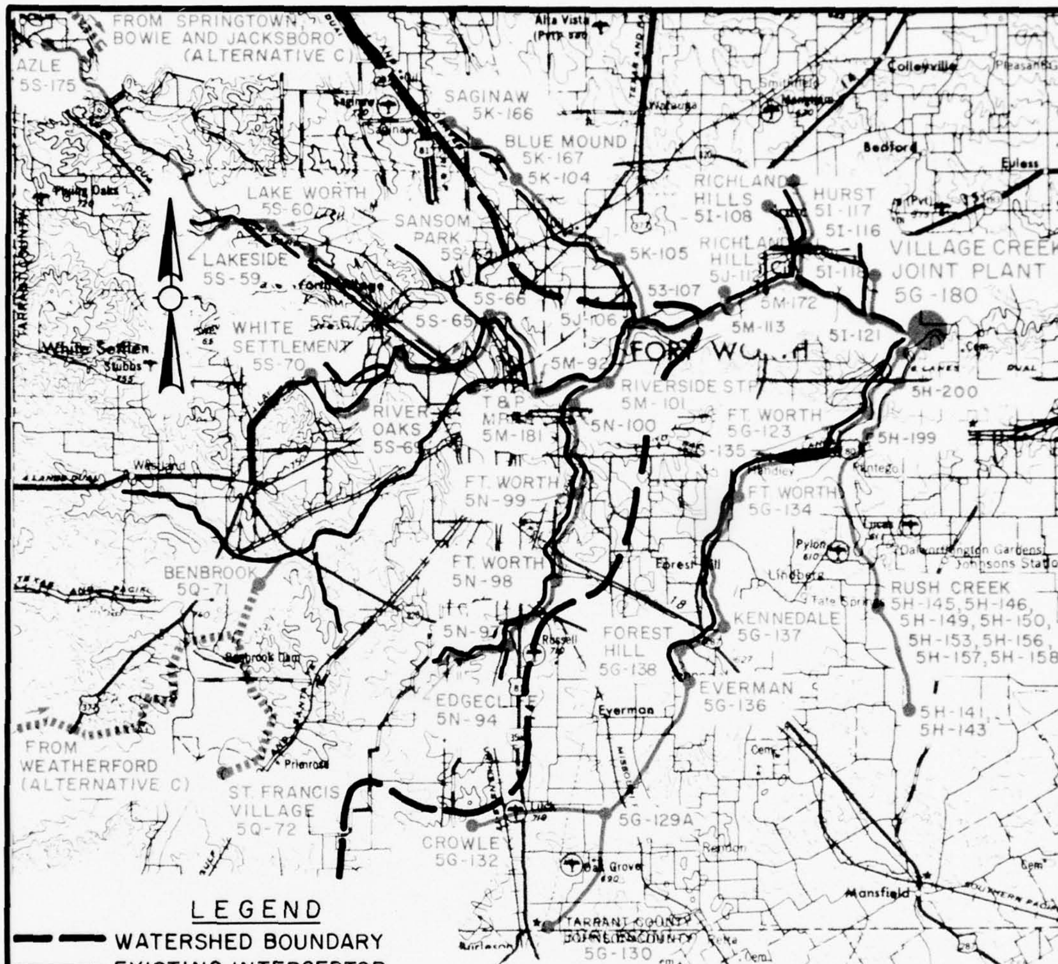
TABLE IX-13. PARTICIPATION IN ALTERNATIVE SEWERAGE SYSTEMS

WEST FORK TRINITY RIVER - WATERSHED 5(1)

(Potential Contributors to the Village Creek Treatment Plant)

Node No.	Populated Area	1990(2) Average Flow (mgd)	Alternative Systems A Present	B Village Creek(3)	C Fully Consolidated
5G-123	Fort Worth*(4)	13.23	J(5)	J	J
5G-130	Burleson	0.44	S(5)	J	J
5G-132	Crowley	0.75	S	J	J
5G-134	Fort Worth*	7.94	J	J	J
5G-136	Everman	0.69	S	J	J
5G-137	Kennedale	1.74	S	J	J
5G-138	Forest Hill	2.12	S	J	J
5H-141	Banfield Mobile Homes	0.20	S	J	J
5H-143	Royal Coach Mobile Homes	0.50	S	J	J
5H-145	L & M Mobile Homes	0.09	S	J	J
5H-146	Dalworthington Gardens	0.61	S	J	J
5H-149	Treetop Mobile Homes	0.28	S	J	J
5H-150	Treetop Mobile Homes South	0.39	S	J	J
5H-153	Tumbleweed Mobile Homes	0.55	S	J	J
5H-156	Wilson	0.27	S	J	J
5H-157	Parsons	0.43	S	J	J
5H-158	Pantego	0.61	S	J	J
5H-199	Arlington*	2.55	S	J	J
5H-200	Arlington*	2.55	S	J	J
5I-117	(North Richland Hills (Watauga (Hurst*	7.96	J	J	J
5I-118	Hurst*	8.84	J	J	J
5I-168	Richland Hills	0.91	J	J	J
5J-112	Richland Hills	0.91	S	J	J
5J-113	Haltom City	8.86	J	J	J
5K-166	Saginaw	1.35	J	J	J
5K-167	Blue Mound	0.44	J	J	J
5K-183	American Manufacturing Co.	0.28	J	J	J
5K-184	Fort Worth Refining Co.	0.26	J	J	J
5M-92	Fort Worth*	21.17	J	J	J
5M-123	Fort Worth*	23.81	J	J	J
5M-181	Texas and Pacific, Missouri Pacific Railroad Co.	0.36	J	J	J
5M-182	American Cyanamid Company	1.25	J	J	J
5N-94	Edgecliff	0.91	J	J	J
5N-98	Fort Worth*	5.29	J	J	J
5N-99	Fort Worth*	7.94	J	J	J
5N-100	Fort Worth*	21.66	J	J	J
5N-128	Fort Worth*	5.29	J	J	J
5Q-71	Benbrook	3.17	J	J	J
5Q-72	St. Francis Village	0.19	S	S	J
5Q-73	Weatherford	2.37	S	S	J
5Q-75	Lake Weatherford	0.15	S	S	J
5Q-76	Aledo	0.05	S	S	J
5S-18	Chico	0.09	S	S	J
5S-19	Bridgeport	0.74	S	S	J
5S-23	Runaway Bay	0.22	S	S	J
5S-25	Wizard Wells	0.01	S	S	J
5S-35	Jermyn	0.13	S	S	J
5S-38	Jacksboro	0.49	S	S	J
5S-39	Decatur	0.67	S	S	J
5S-43	Paradise	0.06	S	S	J
5S-46	Boyd, Aurora, Rhome	0.16	S	S	J
5S-47	Newark	0.10	S	S	J
5S-51,51A	Reno, La Junta Highland Add'n	0.17	S	S	J
5S-52	Springtown	0.17	S	S	J
5S-59	Lakeside	0.71	S	J	J
5S-60	Lake Worth	1.43	J	J	J
5S-63	Sansom Park	1.07	J	J	J
5S-69	River Oaks, Westover Hills	1.12	J	J	J
5S-70	White Settlement,WestworthVillage	3.34	J	J	J
5S-175	Azle	1.31	S	J	J
5T-1	Bowie	1.14	S	S	J
5T-4	Lake Amon Carter	0.10	S	S	J
5T-6	Sunset	0.03	S	S	J
5T-9	Park Springs	0.01	S	S	J
5T-11	Alvord	0.08	S	S	J
	Total Flow	172.71			
Estimated 1990 Flow for Joint Participants (mgd)			147.88	165.58	172.71

Notes:
(1) Except not including part to Elm Fork Trinity River - Watershed 4.
(2) Flows from populated areas not listed are included in the flows shown.
(3) Recommended alternative.
(4) "*" Denotes part of populated area.
(5) "J" Denotes joint participation.
"S" Denotes separate participation.



LEGEND

WATERSHED BOUNDARY
EXISTING INTERCEPTOR (ALSO ALTERNATIVE A)
ALTERNATIVE B (RECOMMENDED)
ALTERNATIVE C
NODE ON INTERCEPTOR, OR LOCAL SEWAGE TREATMENT PLANT
JOINT SEWAGE TREATMENT PLANT

5 0 5
SCALE IN MILES

NOTES:

1. NOT ALL S.T.P.'S IN WATERSHED ARE SHOWN.
2. PARTICIPATION OF ALL S.T.P.'S IN ALTERNATIVE SYSTEMS IS SHOWN IN TABLE IX.

FIG. IX-5 ALTERNATIVE SEWERAGE SYSTEMS (WEST FORK TRINITY - WATERSHED 5)

5 0 5
SCALE IN MILES

JULY, 1970

TABLE IX-14. COST COMPARISONS OF ALTERNATIVE SYSTEMS

WEST FORK TRINITY RIVER - WATERSHED 5[(2)]

	ESTIMATED COSTS OF ALTERNATIVE SYSTEMS[(4)]					
	A Present		B Village Creek		C Fully Consolidated	
Disposition of Existing Plants[(1)]	"1"	"2"	"3"	"2"	"4"	"2"
CAPITAL COSTS ($1,000)						
Construction of Sewage Treatment Plants:						
1. Secondary Treatment Facilities	$45,370	$57,600	$39,040[(3)]	$45,670	$34,500	$39,670
2. Additional Tertiary Treatment Facilities	33,930	33,930	26,540	26,540	23,300	23,300
3. Land	880	1,190	900	1,170	870	1,140
Subtotal	$80,180	$92,720	$66,480	$73,380	$58,670	$64,110
Construction of Interceptors, Pumping Stations, and Force Mains	$24,880	$24,880	$38,970	$38,970	$81,960	$81,960
Total	$105,060	$117,600	$105,450	$112,350	$140,630	$146,070
AVERAGE ANNUAL COSTS ($1,000/Year)						
Amortization (30 Years at 6 1/2%)	$6,920	$7,740	$6,940	$7,400	$9,250	$9,610
Operation and Maintenance	8,950	8,950	8,040	8,040	7,760	7,760
Total	$15,870	$16,690	$14,980	$15,440	$17,010	$17,370

Notes:

(1) Disposition: "1" Denotes utilization of all existing plants.
"2" Denotes no utilization of existing plants.
"3" Denotes utilization of existing plants at sites not served by the joint systems.
"4" Denotes utilization of existing Village Creek plant.

(2) Does not include costs for portion of watershed included with Elm Fork Trinity River - Watershed 4 (See Table IX-12).

(3) Recommended alternative, shown boxed.

(4) Costs for all facilities.

(a) Crowley, Burleson, Everman, Forest Hill and portions of Arlington in the Village Creek and Rush Creek Watershed.

(b) Dalworthington Gardens, Wilson, Parsons, Pantego, and mobile home parks in the Rush Creek drainage area.

(c) Azle and Lakeside in the vicinity of Eagle Mountain Lake and Lake Worth on the West Fork of the Trinity River.

(d) Haltom City and a portion of Richland Hills, which are located near the West Fork about midway between the Riverside and Village Creek treatment plants.

Facilities constructed under Alternative B may be summarized as follows:

(a) About 534,000 l.f. (101 mi) of interceptors.

(b) Three pumping stations and about 10,000 l.f. (2 mi) of force mains.

(c) Expansion of the 45 mgd Village Creek Plant to a capacity of about 166 mgd to treat the estimated flows in 1990 and provision of advanced treatment facilities.

(d) Expansion and/or construction of about 21 additional treatment plants.

Alternative C(Fully Consolidated System). Under this alternative, all the potential contributors listed in Table IX-13 would be served by a single joint sewerage system. The facilities required for this alternative would be as follows:

(a) About 1,533,000 l.f. (290 mi) of interceptiors.

(b) Nine pumping stations and 20,000 l.f. (3.8 mi) of force mains.

(c) Expansion of the 45 mgd Village Creek Plant to a capacity of about 173 mgd by 1990 and construction of advanced treatment facilities. All existing sewage treatment plants would be phased out.

Selection of Recommended System. The Village Creek System (Alternative B) is recommended for the upstream portion of the West Fork Watershed for the following reasons:

1. As indicated by the cost comparisions in Table IX-14, the recommended plan would cost less than the present system by approximately 6 percent. The fully consolidated system, Alternative C, would offer a higher degree of consolidation, but at an unacceptable increase in cost. The cost comparision of Alternative C with Alternative B indicates an additional cost of about 12 to 14 percent to increase the flow to the regional plant by 4 percent, which represents a high marginal cost for increasing the degree of consolidation.

2. The recommended Village Creek joint system would provide the general advantages of consolidation such as attractive possibilities for wastewater reuse, high quality of operation, and flexibility in treatment processes employed to achieve desired water quality.

3. Diversion of sewage from Azle into the joint system would help to protect water quality in Eagle Mountain Lake and Lake Worth.

4. The existing Village Creek Plant site has capability for future expansion.

5. The recommended alternative system makes optimum economic use of existing treatment plants.

CHAMBERS WAXAHACHIE CREEK-WATERSHED 10

The populated areas considered in the investigation of joint facilities for the Chambers-Waxahachie Creek Watershed are listed in Table IX-15, with a designation of their participation in two alternative systems. Although the costs and flows for Midlothian and Sonoma have been presented in the discussion of the Elm Fork and Trinity River watersheds, respectively, they are included again in this discussion. Corsicana, which lies outside the study area, has also been included, because it is relatively large compared to the other communities. In addition Ennis which lies in the Cummins Creek-Watershed 11 is included in this discussion.

As mentioned in the discussion of the Trinity River-Watershed 1, the possibility of conveying the flows from Palmer and the Red Oak Creek area to Sonoma was investigated and found to be more expensive than separate plants for the individual communities.

Additional studies revealed no feasible joint system for any combination of the populated areas considered, due to the small projected populations and large distances between population centers. For purposes of comparison with the cost of separate treatment plants, the cost of a consolidated system serving all the populated areas is presented in Table IX-15 as Alternative B.

Alternative A (Present System Recommended). The estimated costs for ten separate treatment plants serving the populated areas are indicated under Alternative A in Table IX-16. No joint conveyance facilities would be required for this alternative but it would appear convenient for flow from Sonoma to be treated with Ennis sewage.

Alternative B(Consolidated System). The joint plant considered for this alternative would be located near Corsicana, on Waxahachie Creek, and would serve all the populated areas considered. This joint system would provide protection of the water quality in Bardwell Reservoir, by diversion of sewage flows out of the reservoir basin.

Alternative B would involve construction of the following facilities:

(a) About 694,000 l.f. (131 mi) of gravity interceptors.

(b) Four pumping stations and about 30,000 l.f. (5.7 mi) of force mains.

TABLE IX-15. PARTICIPATION IN ALTERNATIVE SEWERAGE SYSTEMS

CHAMBERS-WAXAHACHIE CREEK - WATERSHED 10

Node No.		1990 Average Flow(1) (mgd)	Alternative System A Present(3)	Alternative System B Consolidated
1B-92	Sonoma	0.11	S(2)	J(2)
5C-500	Midlothian	0.37	S	J
10A-80	Alvarado	0.24	S	J
10A-81	Maypearl	0.04	S	J
10A-83	Grandview	0.13	S	J
10A-84	Italy	0.18	S	J
10A-86	Milford	0.05	S	J
10A-97	Corsicana	3.27	S	J
10B-89	Waxahachie	3.42	S	J
11A-94	Ennis	1.89	S	J
	Total Flow	9.70		
Capacity of Joint Treatment Plant (mgd) for 1990 flow			0	9.70

Notes:

(1) Flows from populated areas not listed are included in flows shown.

(2) "S" Denotes separate participation.

"J" Denotes joint participation.

(3) Recommended Alternative.

(c) An advanced wastewater treatment plant, receiving an estimated sewage flow of about 9.7 mgd in 1990.

Selection of Recommended System. The present system (Alternative A) is recommended on the basis of lowest cost. The joint system considered (Alternative B) would be about twice as expensive, as shown by the cost comparison in Table X-16.

REMAINING AREAS - WATERSHEDS 6,7,8,9,12

Brazos River - Watershed 6. About 280,000 acres, or almost one-half, of Parker County lies within the Brazos River Basin. The drainage divide that separates the Brazos Basin on the west from the Trinity basin on the east runs generally north and south across Parker County and passes near the west edge of Weatherford, the county seat. This western portion of the county is a rural area, with no population concentrations of more than a few hundred people. There are fewer than 6,000 people within the area, and little increase in population is expected within the foreseeable future. According to available records there are no municipal sewage treatment plants in the area, and the need for a joint sewerage system is not indicated. Because of the sparse population it is not anticipated that the sewage from the area will have an adverse effect on either the Brazos River or on DeCordova Bend Reservoir, a recently completed mainstem conservation project whose upper reaches extend into the southern edge of Parker County.

Brazos River - Watershed 7. Fewer than 1,500 people live in this 80,000 acre area on the western edge of Johnson County, and the population is not expected to increase substantially beyond this number by the year 2020. The area is rural, with no population centers and contains no municipal sewage treatment plants. It is remote from populous areas, and the need for joint sewerage facilities is not indicated.

Nolands River - Watershed 8. The City of Cleburne, which has a population of 17,800 in 1967, lies in the heart of the 157,000 acre portion of Johnson County drained by the Nolands River, a tributary of the Brazos River. The population of the area is expected to approach 50,000 people by the year 2020, most of whom would live in Cleburne. The Cleburne sewage treatment plant is not in a position to serve economically the upstream communities of Joshua (800 people) and Godley (450 people) because of the prohibitively great interceptor lengths which would be required. Furthermore, consolidation of the sewerage facilities with those of another city is unfeasible because of the great distances involved and the small size of neighboring communities. Waste treatment can best be provided by expansion of existing facilities.

Richland Creek - Watershed 9. Though this area eventually drains into the Trinity River, it does not do so through the ten-county NCTCOG area. Having an expected population of no more than 300 people by the year 2020, this 8,200-acre remote rural area contains no sewage collection or treatment facilities.

Sabine River - Watershed 12. Royse City, with a population of 1,200 in 1967, is the largest population center in this 72,000-acre area. Population projections indicate that by the year 2020 about 18,000 people will inhabit the area, most of whom are expected to live in Royse City. The area is tributary to Lake Tawakoni, a Sabine River Authority reservoir from which the City of Dallas obtains a sizeable portion of its water supply. There are no sewage treatment plants in the Sabine watershed which are conveniently located to receive the wastes from Royse City.

TABLE IX-16. COST COMPARISONS OF ALTERNATIVE SYSTEMS

CHAMBERS-WAXAHACHIE CREEK - WATERSHED 10

	Estimated Costs of Alternative Systems: A — Present		B — Consolidated[4]
Disposition of Existing Plants[1]	"1"	"2"	"2"
CAPITAL COSTS ($1,000)			
Construction of Sewage Treatment Plants:			
1. Secondary Treatment Facilities	$3,820[3]	$7,770	$4,930
2. Additional Tertiary Treatment Facilities	4,580	4,580	2,900
3. Land	10	10	20
Subtotal	$8,410	$12,360	$7,850
Construction of Interceptors, Pumping Stations, and Force Mains	0	0	30,540
Total	$8,410	$12,360	$38,390
AVERAGE ANNUAL COSTS ($1,000/Year)			
Amortization (30 years at 6 1/2%)	$550	$810	$2,530
Operation and Maintenance	980	980	840
Total	$1,530	$1,790	$3,370
Total Annual Costs, Excluding Costs for Sonoma, Midlothian, and Corsicana	$940	$1,030	

Notes:

(1) Disposition: "1" Denotes retention of all existing plants.
"2" Denotes phasing out of all existing plants.

(2) Costs for all facilities.

(3) Recommended alternative, shown boxed.

(4) No existing plant at joint treatment plant site.

Consideration has been given in this study to pumping Royse City sewage westward to the East Fork Trinity River system by way of Rockwall. This was found to be uneconomical, however, on the basis of estimated future sewage flows. The most practical solution to this waste disposal problem is for Royse City to treat its own sewage to maintain the high water quality in Lake Tawakoni, which is about fifteen miles downstream. A separate treatment plant is now planned for Royse City, as discussed in Chapter IV.

REGIONAL SYSTEM ALTERNATIVE

As used herein, the term "joint sewerage system" refers to a sewerage system which serves two or more communities usually in one watershed while a "regional" system is considered to serve a number of watersheds. The investigations for individual watersheds indicate the feasibility of six joint sewerage systems for the study area, associated with the following existing plants: Dallas-White Rock, Dallas-South Side, TRA Ten Mile Creek, Garland-Duck Creek, TRA Central, and Fort Worth-Village Creek. This section considers the possibility of a regional system serving two or more of these joint systems as an alternative to the joint systems.

For the regional system alternative, the joint treatment plant sites have been considered as local collection points, and the joint interceptor systems have been ignored. The only exception is in the East Fork system where the flows for the communities downstream from the Garland-Duck Creek plant would enter a regional interceptor directly, without being pumped upstream to the Garland-Duck Creek plant. In all other cases, the flows which might enter a regional interceptor directly from local communities have been considered as negligible compared to the flows conveyed between joint treatment plants.

In the regional system alternative, the treatment plant would be located near the mouth of the East Fork of the Trinity River, with large interceptors extending upstream along the Trinity River and the West Fork, up the East Fork, and up Ten Mile Creek to each of the six joint plant sites. Facilities required for the regional system would include 416,000 l.f. (79 mi) of gravity interceptor, and a tertiary treatment plant which would receive an estiamted flow of about 574 mgd in 1990.

The estimated cost of the regional system is about one percent less than the cost of the recommended joint plants, as shown in Table IX-17. However, it should be noted that the cost of the regional plant has been estimated by extrapolation of the generalized cost curves; whereas for flows of the magnitude considered, it is unlikely that one would obtain the degree of economy of scale indicated in the generalized cost curves.

The interceptor sizes computed in this cost comparison range up to 20 ft in diameter, with unit costs obtained by an extrapolation of Fig. VII-1, whereas in fact the diameter of Class III thick-wall pipe, delivered to site (the type considered in the derivation of Fig. VII-1f) would be limited to about 10-ft because of difficulty of road transport of larger sizes. It is more realistic to consider the flows conveyed by two or more parallel interceptors in which case the cost of interceptor construction for the regional system might be somewhat greater than the $189,830,000 shown. Therefore, despite the appearance of Table IX-17, it is considered that there is no appreciable cost advantage to the regional system alternative.

TABLE IX-17. COST COMPARISON FOR REGIONAL SYSTEM

	ESTIMATED COSTS ($1,000)		
	Joint Plants		Regional System[4]
Disposition of Existing Plants[1]	"1"	"2"	
CAPITAL COSTS ($1,000)			
Construction of Sewage Treatment Plants:			
1.Secondary Treatment Facilities	$127,820[3]	$170,270	$95,900
2.Additional Tertiary Treatment Facilities	100,460	100,460	56,500
3.Land	2,820	3,990	3,400
Subtotal	$231,100	$274,720	$155,800
Construction of Interceptors[2]	0	0	189,830
Total	$231,100	$274,720	$345,630
AVERAGE ANNUAL COSTS ($1,000/Year)			
Amortization (30 Years at 6 1/2%)	$15,210	$18,080	$22,800
Operation and Maintenance	29,400	29,100	21,300[5]
Total	$44,610	$47,180	$44,100

Notes:

(1) Disposition: "1" Denotes utilization of existing plants.
"2" Denotes no utilization of existing plants.
(2) Not including interceptors tributary to joint plant sites.
(3) Recommended alternative.
(4) There is no existing plant at the regional plant site.
(5) Costs for all regional facilities.

In view of the probable cost advantage, the six joint systems are recommended in preference to a single regional system because a regional system would deprive the Upper Trinity River of practically all flow during the dry summer season. In contrast, the joint systems would provide treated effluent for power plant cooling, as discussed in Chapter XI, for navigation, and for other water uses in the Dallas-Fort Worth metropolitan area throughout the year.

SUMMARY OF RECOMMENDED ALTERNATIVES

A summary of the estimated cost and flows is presented in Chapter X, which contains a detailed description of the recommended alternatives, including proposed staging of construction. Six joint sewerage systems are recommended in the study area based on total estimated costs and without regard to the effects of Federal and State assistance. The nucleus for each of these systems either now exists or is under construction.

CHAPTER X

RECOMMENDED REGIONAL SEWERAGE PLAN

GENERAL CONSIDERATIONS

In each major watershed of the study area, the recommended plan consists of a combination of separate treatment plants and one or more systems of interceptors carrying flows to a joint plant, as discussed in Chapter IX. The recommended plan for the entire study area is indicated on Fig. X-1, appended to this volume. The recommended regional system presented herein would collect about 92 percent of the sewage in the study area by 1990, in six joint plants which will permit phasing out of 46 existing local plants. The recommended regional system will involve the construction of 24 pumping stations and 351 miles of gravity and pressure interceptors.

Outlying communities will continue to be served by separate plants ,79 of which are now in existence, and 25 new plants will have to be constructed. It is within the scope of this report to decide only whether a given sewage treatment plant should be retained as a separate plant, or whether it should be relieved by the regional system and phased out. For each major watershed of the study area the plants that are to be retained, expanded, or constructed as separate plants have been tabulated in Chapter IX, and are listed later in this chapter as each major watershed is discussed. (These separate plants, lying outside the approximate limit of the area to be served by joint systems, are not shown on Fig. X-1.) Projected populations served by the proposed separate plants are listed in Table V-3; tributary flows and loads, including those from the six industries described in Chapter IV and Appendix C, are listed in Table V-6. Construction costs and annual operation and maintenance costs may be estimated from curves presented in Fig. VII-1.

In this report, the terms "force main" and "pressure interceptor" are equivalent. The interceptors recommended do not include local collection systems, street laterals, or submain sewers, but constitute only links between potential and/or actual sewage treatment plant sites, as discussed in Chapter IX.

STAGING OF CONSTRUCTION

In general, staging of construction of the recommended sewerage facilities is based upon bringing a maximum quantity of sewage to the proposed joint plants at a minimum initial cost. This means that the facilities most urgently required as parts of the recommended systems are the consolidated or joint treatment plants and the conveyance facilities needed to bring a significant portion of the sewage to the plants. These facilities are included in the initial construction program. In order to achieve water quality objectives within a reasonable time span, it is further considered that tertiary treatment will be provided at all plants by the year 1990. As stated in Chapter VI, needed treatment plant capacity in a given year is based on the estimated average flow to the plant in that year. Needed gravity interceptor capacity is based on peak flow plus a per capita allowance for infiltration. Projected populations served by existing plants in the years 1970, 1975,1980,1990, 2000, and 2020 are derived from Table V-3; flows and loads to the plants projected for the same years are derived from Table V-6. The needed capacity of any existing facility may, therefore, be computed for those years, and by interpolation it may be determined when the existing or expanded

capacity of the facility is expected to be exceeded. As stated in Chapter VI, parts of the regional collection system that are needed to relieve overloaded facilities before 1975 are scheduled for the Initial Stage of construction. Portions needed not before 1975 but before 1990 are scheduled for Future Stage 1, and portions needed not before 1990 but before 2020 are scheduled for Future Stage 2. Construction costs for new facilities are derived using the generalized cost curves presented on Fig. VII-1. As stated therein, the cost estimates include a 25 percent allowance for engineering, administration and legal services during design and construction phases. The costs in this report have been adjusted to an estimated Engineering News-Record (ENR) Construction Cost Index of 1100 for the Dallas area. Annual operation and maintenance costs of a treatment plant or interceptors, also estimated using curves presented on Fig. VII-1, are based on the average daily flow through the facility during the designated period.

As stated in Chapter VI and in Chapter IX, the design year for all proposed sewage treatment plants and pumping stations is 1990. Thus, construction for recommended plants and pumping stations is scheduled for the Initial Stage or Future Stage 1 Programs. Subsequent expansion for 2020 design flows is scheduled for Future Stage 2. On the other hand, gravity and pressure interceptors are designed initially for 2020 flows, as explained in Chapter VI.

Specific watershed recommendations presented in this report are not considered to be absolute because of the generalized nature of the studies. The recommendations are, however, meant to be utilized as a basis of comparison with other possible alternative systems on a watershed basis. Detailed studies for specific localities and projects may indicate that size, location, and staging of facilities should depart from the recommendations herein.

LOW FLOW AUGMENTATION ESTIMATES

During the dry weather, the flow in the Trinity River and its tributaries is composed principally of sewage treatment plant effluent; hence, the degree to which sewage is treated has a direct relationship to water quality in the river. Water quality requirements for the Trinity River and its principal tributaries have been developed by the Texas Water Quality Board (TWQB) as stated in Chapter III and presented in Appendix A. One of the more significant water quality parameters is the dissolved oxygen (D.O.) concentrations. For the Trinity River, from the tidal estuary to Rosser and upstream to the West Fork headwater, for the Elm Fork, and for the East Fork, the TWQB requires that the D.O. level be not less than 4.0 mg/l.

An alternative to adequate sewage treatment considered acceptable in some locations has been the provision of pollutant-free dilution water to keep D.O. concentrations above minimum levels. Such dilution water, needed especially at times of low flow, is called "low-flow augmentation."

Organic and chemical pollutants in the river tend to deplete a stream's supply of dissolved oxygen; atmospheric oxygen diffuses into water through the surface to replenish the supply. To ensure that a required concentration of D.O. is maintained in the stream, it is necessary not only to provide sufficient D.O. in the stream at a given point of measurement, but also to limit the biochemical oxygen demand (BOD) of the pollutants to a sufficiently low level that oxygen will not be depleted so much faster

than it is replaced by reaeration that the D.O. concentration "sags" below the required level.

The analysis used to estimate the low flow augmentation required, presented in detail in Appendix G, is based on the Streeter-Phelps analysis of stream deaeration and reaeration, and takes into account carbonaceous BOD only. It does not recognize the effects of either nitrogen or phosphorus on the receiving water.

As explained in Appendix G, a representative water temperature for hot-weather, low-flow conditions in the study area is about 30°C. At this temperature, the saturation concentration of dissolved oxygen in water at Standard Pressure is 7.4 mg/1, and the deaeration rate k_1, is estimated to be 0.36 per day. The ratio k_2/k_1 of the rate of reaeration to the rate of deaeration is estimated to be 2. The ratio of the concentration L of ultimate BOD to the concentration B of 5-day 20°C BOD is 1.46. The required augmentation flow Qa is expressed in terms of the discharge, carbonaceous BOD concentration, and D.O. concentration of the treated sewage effluent and of the natural river flow, and in terms of the BOD and D.O. concentrations of the augmentation water, as well as of the ratio k_2/k_1, and of the saturation of D. O. at 30° C.

In application of the analysis, it is further assumed that:

1. At a sewage treatment plant, augmentation water is available in any desired quantity (without consideration of physical or economic limitations).

2. The augmentation water is saturated with dissolved oxygen (whereas, in fact, water from a reservoir may not be saturated with oxygen).

3. There is no BOD in the augmentation water (whereas, in fact, water from a reservoir may have some BOD).

4. Advanced wastewater treatment plants with effluent aerators can provide a D.O. concentration of 4 mg/1 in the effluent. Secondary plants (without such aerators) may yield effluents with D. O. concentrations of about 2 mg/1.

5. BOD and D.O. levels are controlled so that, according to the Streeter-Phelps analysis, the dissolved oxygen level will not "sag" below the statutory minimum concentration of 4.0 mg/1. That is, when the D. O. equals 4.0 mg/1, the BOD concentration is that which will cause the rate of reaeration to be just equal to the rate of deaeration. According to the Streeter-Phelps analysis, this concentration is 4.7 mg/1 for 5-day 20° C BOD for the conditions assumed.

6. In a river just upstream of a sewage treatment plant outfall, the concentrations of D.O. and BOD are at the critical values of 4.0 mg/1 and 4.7 mg/1, respectively.

The augmentation flows required for the six proposed joint plants, as determined by this analysis, are presented in Table X-1 for secondary and for advanced treatment plant effluent. The minimum degree of treatment now required by the Texas Water Quality Board (TWQB) is secondary treatment, which may be considered to remove about 90 percent of the carbonaceous BOD and roughly 30 percent of the nitrogenous BOD and to release an effluent with a D. O. concentration of about 2 mg/1. The analysis presented in Appendix G indicates that when secondary treatment is provided, the augmentation flow required to maintain a minimum D. O. concentration of 4.0 mg/1 is approximately twice the rate of effluent discharge, assuming that the water available for augmentation is totally free of BOD and saturated with D. O. as shown in Table X-1.

In general, water available for dilution will not be entirely free of BOD and will not be saturated with oxygen. As noted in Appendix G, a greater quantity of augmentation flow will be required if it contains BOD and/or an oxygen deficit.

The process by which nitrogenous BOD is exerted has not been satisfactorily formulated mathematically, but dilution water requirements will increase generally in proportion to the concentration of nitrogenous BOD in the effluent. The total nitrogenous BOD in raw sewage is of roughly the same magnitude as the ultimate carbonaceous BOD. Secondary treatment may be assumed to remove about 30 percent of the nitrogenous BOD, and advanced or tertiary treatment may reduce nitrogenous BOD to a concentration of about 6 mg/1. The quantities of augmentation flow needed to maintain the required D. O. level will actually be greater than the quantities estimated, because of the imperfect quality of water available for augmentation and due to the presence of nitrogenous BOD in the sewage effluent.

Advanced wastewater treatment processes such as a two stage activated sludge process, denitrification, and aeration of the effluent (shown schematically on Figure VI-1) may be expected to remove about 98 percent of the carbonaceous BOD, to reduce total nitrogenous BOD to about 6 mg/1 and to produce an effluent with a D. O. concentration of about 4 to 5 mg/1. The analysis presented in Appendix G shows that little or no dilution water would be needed with such effluents.

It should be kept in mind that the estimates of low flow augmentation requirements are approximate only, because of the imprecise and incomplete nature of the deaeration-reaeration analysis. Yet the degree of accuracy provided is sufficient to indicate that to provide dilution water for adequate low flow augmentation for secondary sewage treatment, the water demands for the North Central Texas region would be roughly tripled, since the required augmentation flow is estimated to be about twice the discharge of plant effluent to the streams. Appropriate advanced treatment, on the other hand, not only would eliminate the need for low flow augmentation but in addition would provide a much greater degree of nitrogen and phosphate removal than secondary treatment.

TABLE X-1. ESTIMATED LOW FLOW AUGMENTATION REQUIREMENTS

Joint Plant	1990 Average Discharge Q_i (2) (mgd)	Estimated Flow in River Q_r (2,3) (mgd)	Required Flow Augmentation, Q_a (2,4): With Secondary Treatment (5) (mgd)	Required Flow Augmentation, Q_a (2,4): With Advanced Treatment (6) (mgd)
Fort Worth - Village Creek (5G-180)	165.60	0	354.0	1.0
TRA-Central (4A-166)	111.88	165.60	221.0	0.7
Dallas - White Rock (1I-175)	139.70	277.48	262.0	0.8
Dallas - South Side (1F-146)	43.17	417.18	59.6	0.2
TRA-Ten Mile Creek (1D-161)	16.46	0	35.2	0.1
Garland - Duck Creek (3D-23)	91.23	0	195.5	0.6
Totals	568.04		1,127.3	3.4

Notes:

(1) Only carbonaceous BOD (not nitrogenous BOD) considered.

(2) The symbols Q_i, Q_r, and Q_a are as defined in Appendix G.

(3) Estimated for summer low flow conditions, with D.O. of 4.0 mg/1 and BOD of 4.7 mg/1 assumed at sag point. Zero natural flow assumed under summer low flow conditions.

(4) Dilution water assumed to be saturated with D.O. (7.4 mg/1), with BOD = 0.

(5) Secondary effluent assumed to have D.O. = 2.0 mg/1, BOD = 25 mg/1.

(6) Tertiary effluent assumed to have D.O. = 4.0 mg/1, BOD = 5 mg/1.

RECOMMENDED SEWERAGE SYSTEMS

GENERAL

The recommended sewerage system for each major watershed is discussed below. The projected population served by each proposed joint plant, the projected flows and loads to each joint plant, the extent of the system of interceptors, and the construction and operation and maintenance costs for each system are tabulated.

Projected average flows to the joint plants for the years 1975, 1990, and 2020 are shown. The 1990 average flows shown in this Chapter may differ slightly from those indicated in Chapter IX by an amount equal to the 1990 average flow from communities to be served by the system in 2020 but not yet served in 1990. Treatment plant cost estimates presented below are based on construction of full advanced wastewater treatment facilities.

The annual operation and maintenance costs for full advanced sewage treatment plants and pump stations are based on the capacity of each facility, and reflect the cost of running the whole facility, including existing components, not just additions recommended in this report. Annual operation and maintenance costs for gravity and pressure interceptors are estimated at 0.25 percent of the construction cost of new facilities recommended in this report.

Costs have been adjusted to an estimated Engineering News-Record (ENR) Construction Cost Index of 1100 for the Dallas area. Land costs are included.

TRINITY RIVER - WATERSHED I

The joint sewerage systems proposed for Watershed 1 are shown on Fig. X-2. Projected populations to be served by each of the three proposed joint plants, and projected flows and loads to these plants in 1975, 1990, and 2020, are presented in Table X-2.

The proposed system of new and relief interceptors, totalling 50 miles, is described in Table X-3. Staging and estimated construction costs of the proposed interceptors are described in Table X-4. Construction and operation and maintenance costs for each of the joint systems proposed for Watershed 1 are summarized in Table X-5.

Dallas-White Rock Joint System. A significant degree of consolidation already exists in the White Rock Creek, Fair Park, Coombs Creek areas, and the areas neighboring the Dallas Sewage Treatment Plant (1I-176) and the Dallas-White Rock Sewage Treatment Plant (1I-175).

It is recommended that these plants, considered in this report as one plant with a capacity of 90 mgd, be expanded by 1975 to provide advanced treatment to a 1990 capacity of about 140 mgd, with an estimated construction cost of $37,320,000 including expansion of existing secondary facilities. The construction cost of subsequent (Future Stage 2) expansion to a 2020 capacity of about 200 mgd is estimated to be $29,470,000. While 45 acres of additional site area are indicated, based on present processes and estimated future flows, no additional area is available at this site. Actual site area requirements are expected to be less than those indicated, as a result of anticipated improvements in plant processes.

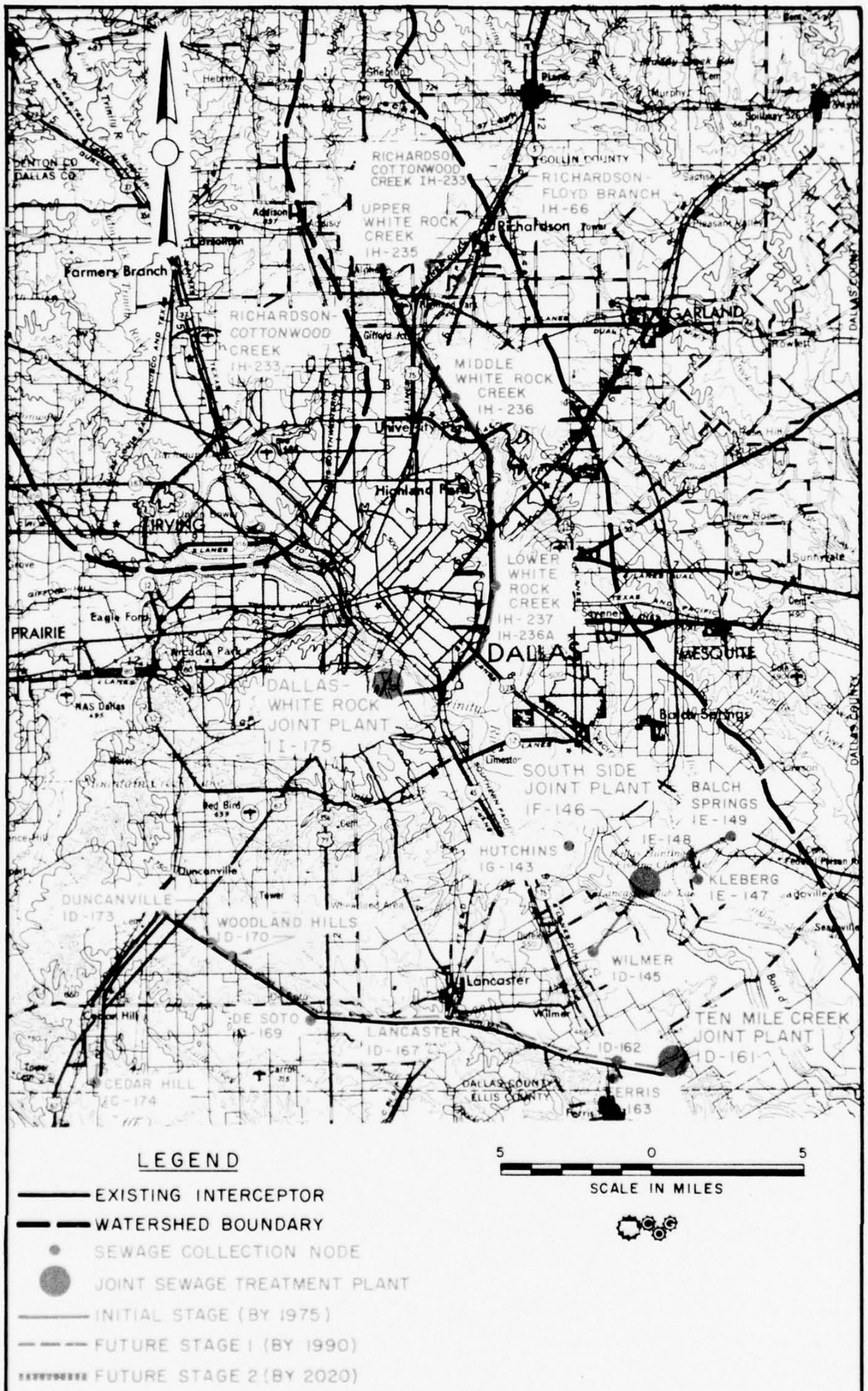


FIG. X-2 RECOMMENDED SEWERAGE SYSTEM (TRINITY RIVER WATERSHED I)

JULY, 1970

469-13854

TABLE X-2. POPULATION SERVED BY, FLOWS AND LOADS TO, JOINT PLANTS

(Trinity River - Watershed 1)

	YEAR		
	1975	1990	2020
Dallas - White Rock Joint Plant (Existing Capacity - 90 mgd) (1I-175)			
Population Served	878,100	1,123,500	1,311,000
Average Sewage Flow (mgd)	95.20	139.71	200.00
Average BOD Load (lb/day)	224,520	297,090	372,100
Average SS Load (lb/day)	230,910	317,180	395,900
Dallas-South Side Joint Plant (Existing Capacity - 7.0 mgd) (1F-146)			
Population Served	238,000	348,170	526,100
Average Sewage Flow (mgd)	25.73	43.18	80.51
Average BOD Load (lb/day)	59,480	90,520	147,300
Average SS Load (lb/day)	61,860	97,470	157,800
Ten Mile Creek Joint Plant (Existing Capacity - 7.0 mgd) (1D-161)			
Population Served	58,910	133,100	289,600
Average Sewage Flow (mgd)	6.32	16.45	44.19
Average BOD Load (lb/day)	14,550	34,370	80,700
Average SS Load (lb/day)	15,180	37,090	86,700

TABLE X-3. RECOMMENDED INTERCEPTING SEWERS

(Trinity River - Watershed 1)

From Node	To Node	Interceptor Name	Length (l.f.)	Diameter (in)	Type of Interceptor
1H-66	1H-70	Floyd Branch	15,400	30	Gravity
1H-233	1H-70	Cottonwood Creek Relief	14,600	24-33	Gravity
1H-235	1H-70	White Rock Creek Relief	17,000	42	Gravity
1H-70	1H-236	White Rock Creek Relief	10,600	48	Gravity
1H-236	1H-236A	White Rock Creek Relief	33,300	72	Gravity
1H-236A	1I-175	White Rock Creek Relief	28,100	84-96	Gravity
1D-145	1F-146	Wilmer - South Side	10,000 3,800	30 24	Gravity Pressure
1E-147	1E-148	Kleberg	5,200	36	Gravity
1E-149	1F-146	Balch Springs - South Side	11,700	36-48	Gravity
1C-174	1D-161	Ten Mile Creek Relief	129,000 13,000	30-72 30	Gravity Pressure
1D-163	1D-162	Ferris	2,500	24	Gravity

Subtotals:

Gravity Interceptor Length	277,400 l.f. (53 miles)
Pressure Interceptor Length	16,800 l.f. (3 miles)
Watershed Total Length	294,200 l.f. (56 miles)

Note:

Lengths are estimated from United States Geological Survey topographic maps of the study area (Scale 1:24,000).

TABLE X-4. STAGING AND CONSTRUCTION COSTS OF PROPOSED INTERCEPTING SEWERS[1]

(Trinity River - Watershed 1)

From Node	To Node	Interceptor Name	Initial Stage (By 1975)	Future Stage 1 (By 1990)	Future Stage 2 (By 2020)
1H-66	1H-70	Floyd Branch		$540,000	
1H-233	1H-70	Cottonwood Creek Relief		480,000	
1H-235	1H-70	White Rock Creek Relief		810,000	
1H-70	1I-175	White Rock Creek Relief	$7,310,000		
1D-145	1F-146	Wilmer - South Side	710,000		
1E-147	1E-148	Kleberg	220,000		
1E-149	1F-146	Balch Springs - South Side	1,070,000		$820,000
1C-174	1D-161	Ten Mile Creek Relief		9,440,000	500,000
1D-163	1D-162	Ferris		80,000	
		Subtotals	$9,310,000	$11,350,000	$1,320,000
		Watershed Total, All Stages			$21,980,000

Note:

(1) Costs shown are for gravity interceptors, pressure interceptors, and pumping stations, and are based on an ENR Construction Cost Index of 1100. Land costs are included.

TABLE X-5. SUMMARY OF PROJECT CONSTRUCTION AND OPERATION AND MAINTENANCE COSTS

(Trinity River - Watershed 1)

	Estimated Construction Costs (1)			
	Initial Stage (By 1975)	Future Stage 1 (By 1990)	Future Stage 2 (By 2020)	Totals
DALLAS - WHITE ROCK JOINT TREATMENT PLANT (11-175)				
Treatment Plant	$37,320,000	-	$29,470,000	$66,790,000
Interceptors:				
Gravity	7,310,000	$1,830,000	-	9,140,000
Pressure	-	-	-	-
Pumping Stations	-	-	-	-
TOTAL CONSTRUCTION COSTS	$44,630,000	$1,830,000	$29,470,000	$75,930,000

	Estimated Annual Operation and Maintenance Costs (2)		
	First Year 1975	Average 1975-1990	Average 1990-2020
White Rock Joint Treatment Plant	$5,730,000	$6,970,000	$9,380,000
Interceptors:			
Gravity	20,000	20,000	20,000
Pressure	-	-	-
Pumping Stations	-	-	-
SUBTOTALS	$5,750,000	$6,990,000	$9,400,000

(1) Based on an ENR Construction Cost Index for Dallas of 1100. Land costs are included.

(2) Costs shown for sewage treatment plants and pumping stations are based on total average flow. Costs shown for gravity and pressure interceptors are 0.25 percent of construction cost shown in first part of this table.

TABLE X-5. SUMMARY OF PROJECT CONSTRUCTION AND OPERATION AND MAINTENANCE COSTS (Continued)

(Trinity River - Watershed 1)

	Estimated Construction Costs[1]			
	Initial Stage (By 1975)	Future Stage 1 (By 1990)	Future Stage 2 (By 2020)	Totals
DALLAS - SOUTH SIDE JOINT TREATMENT PLANT (1F-146)				
Treatment Plant	$21,150,000	-	$20,720,000	$41,870,000
Interceptors:				
Gravity	1,130,000	-	-	1,130,000
Pressure	110,000	-	-	110,000
Pumping Stations	760,000	-	820,000	1,580,000
TOTAL CONSTRUCTION COSTS	$23,150,000	-	$21,540,000	$44,690,000

	Estimated Annual Operation and Maintenance Costs[2]		
	First Year 1975	Average 1975-1990	Average 1990-2020
South Side Joint Treatment Plant	$1,880,000	$2,410,000	$3,970,000
Interceptors:			
Gravity	Nil	Nil	Nil
Pressure	Nil	Nil	Nil
Pumping Stations	20,000	20,000	40,000
SUBTOTALS	$1,900,000	$2,430,000	$4,010,000

Note: Land costs are included.

TABLE X-5. SUMMARY OF PROJECT CONSTRUCTION AND OPERATION AND MAINTENANCE COSTS (Continued)

(Trinity River - Watershed 1)

	Estimated Construction Costs(1)			
	Initial Stage (By 1975)	Future Stage 1 (By 1990)	Future Stage 2 (By 2020)	Totals
TEN MILE CREEK JOINT TREATMENT PLANT (1D-161)				
Treatment Plant	-	$8,930,000	$16,640,000	$25,570,000
Interceptors:				
Gravity	-	8,730,000	-	8,730,000
Pressure	-	460,000	-	460,000
Pumping Stations	-	330,000	500,000	830,000
TOTAL CONSTRUCTION COSTS	-	$18,450,000	$17,140,000	$35,590,000

	Estimated Annual Operation and Maintenance Costs(2)		
	First Year 1975	Average 1975-1990	Average 1990-2020
Ten Mile Creek Joint Treatment Plant	$200,000	$940,000	$2,160,000
Interceptors:			
Gravity	-	20,000	20,000
Pressure	-	Nil	Nil
Pumping Stations	-	10,000	30,000
SUBTOTALS	$200,000	$970,000	$2,210,000

Note:

Land costs are included.

It is proposed that the Richardson-Floyd Branch Sewage Treatment Plant (1H-66) be phased out, and that the Floyd Branch interceptor be built, by 1990 (Future Stage 1). The Cottonwood Creek Interceptor (1H-233 to 1H-70) should be relieved by 1990. It is expected that the White Rock Creek Interceptor will require relief, portions by 1975 (Initial Stage) and other portions by 1990 (Future Stage 1). Construction of 23 miles of new and relief gravity interceptors in the initial and Future Stage 1 programs is projected to cost about $9,140,000. No pumping stations or force mains are proposed for this area. Major improvements needed in the sewerage system are considered to be within the Dallas system.

Dallas-South Side Joint System. There are at present plans to divert flows from the Five Mile Creek and Elam Creek areas, now served by the Dallas-White Rock Plant (1I-175 and 1I-176), to the Dallas-South Side Plant (1F-146). These plans are considered reasonable and should be continued. It is proposed herein to include flows from Hutchins in the Five Mile Creek interceptor to the South Side plant (not shown on Fig. X-1 or Fig. X-2), so that the Hutchins Sewage treatment plant (1G-143) may be phased out as soon as that interceptor is completed. It is further proposed that new interceptors from Wilmer (1D-145), Kleberg (1E-147), and Balch Springs (1E-149) to the South Side plant be built by 1975 (Initial Stage) permitting the phasing out of sewage treatment plants serving those three communities. The Wilmer and Kleberg plants are judged to be inadequate, as shown in Table VIII-1.

Initial Stage construction of the South Side plant to a 1990 capacity of about 43 mgd is estimated to cost about $21,150,000 and subsequent Future Stage 2 expansion to the 2020 capacity of about 80 mgd is estimated to cost approximately $20,720,000. The existing lagoons are not considered in these estimates but could be utilized for effluent polishing or storm water detention. Adequate land has been acquired by the City of Dallas for all anticipated future requirements.

Construction of about five miles of proposed gravity interceptors, 3,800 l.f. of pressure interceptors, and two pumping stations is estimated to cost about $2,000,000. Expansion of the pumping stations after 1990 to 2020 capacity is estimated to cost $820,000.

Ten Mile Creek Joint System. No extension of the existing TRA Ten Mile Creek interceptor beyond its present service area is recommended. It is anticipated, however, that the interceptor serving Ferris, Lancaster, DeSoto, Woodland Hills, Duncanville, and Cedar Hill will need to be relieved by a parallel interceptor by 1990 (Future Stage 1). The 7 mgd TRA Ten Mile Creek Sewage Treatment Plant (1D-161) now under construction will require expansion by that time.

Construction of about 25 miles of relief gravity interceptor, 13,000 l.f. of pressure interceptor, and expansion of one pumping station, scheduled for Future Stage 1, is estimated to cost approximately $9,520,000 and subsequent (Future Stage 2) expansion of the pumping station is estomated to cost $500,000. Expansion of the Ten Mile Creek Sewage Treatment Plant including provision of advanced treatment with a 1990 capacity of about 16.5 mgd is estimated to cost $8,930,000. Subsequent (Future Stage 2) expansion to a 2020 capacity of about 44 mgd is estimated to cost $16,640,000. An additional 30 acres of land at the treatment site is considered desirable based on present process requirements and estimated future flows, and consideration should be given to its acquisition.

Southeast Area. It is recommended that existing sewage treatment plants in the relatively isolated communities of Kerens, Sonoma, and Palmer be retained and expanded as necessary, and that separate plants to serve Lower, Middle, and Upper Red Oak Creek be built as needed. Advanced treatment should be provided where feasible to avoid pollution of local streams and of the Trinity River. The estimated construction costs for plants in the Southeast Area are summarized in Table X-19, presented hereinafter.

CEDAR CREEK - WATERSHED 2

It is recommended that the 10 local treatment plants serving Mabank, Malakoff, Athens, Trinidad, Wills Point, Terrell, Kaufman and Kemp be retained and expanded as necessary. It is further recommended that advanced treatment be provided, where feasible, to all wastewater before discharge to the watershed of the Cedar Creek Reservoir and to the reservoir itself to avoid pollution and to retard eutrophication of that lake. Staging of expansion of these treatment plants is shown in Table X-19, presented hereinafter.

DUCK CREEK JOINT SYSTEM

The joint sewerage system proposed for the East Fork of the Trinity River - Watershed 3 is shown on Figs. X-1 and X-3. Projected populations to be served by the Duck Creek Joint Plant, and projected flows and loads to this plant in 1975, 1990 and 2020 are presented in Table X-6. The required new and relief interceptors, totalling 92 miles, are listed in Table X-7. Staging and estimated construction costs of the proposed interceptors are described in Table X-8. Construction and operation and maintenance costs for the joint system are summarized in Table X-9.

It is proposed that separate treatment plants continue to serve areas north of McKinney and south of Seagoville, as shown on Fig. X-1 appended to this volume, and on Fig. X-3. Existing separate plants at Van Alstyne, Anna, Princeton, Tom Bean, Blue Ridge, Trenton, Leonard, Farmersville, Forney, and Crandall should be retained, and in most cases expanded to accept greater flows and to provide adequate advanced treatment. Existing treatment plants at McKinney (north and south), Rockwall, Garland (Rowlett Creek), Allen, Plano, Mesquite, Wylie, and Seagoville should be phased out as the joint system is built. Sewage from McKinney, Plano, Garland, Rockwall, Health, Mesquite, and Seagoville will be treated at a proposed joint plant at the site of the present Garland-Duck Creek Sewage Treatment Plant.

Inital Stage. It is proposed that the existing Duck Creek Sewage Treatment Plant (3D-23) be expanded by 1975 (Initial Stage) to provide advanced treatment with a 1990 capacity of about 91 mgd, at an estimated construction cost of about $37,930,000. Subsequent (Future Stage 2) expansion to a 2020 capacity of about 155 mgd is estimated to cost about $30,630,000.

It is proposed in the Initial Stage of Construction that The Rowlett Creek Interceptor be built, from Plano (3D-26), via Richardson (3E-31), Garland (3E-33), the Garland-Rowlett Sewage Treatment Plant (3E-40), and Rose Hill to the intersection with the Duck Creek Interceptor (3D-45). The 81,900 l.f. of gravity interceptors, 3,600 l.f. of pressure interceptors, and two pumping stations are estimated to cost about $13,930,000. Subsequent (Future Stage 2) expansion of the two pumping stations is estimated to cost about $2,700, 000. The Sachse interceptor from Sachse (3E-35) to

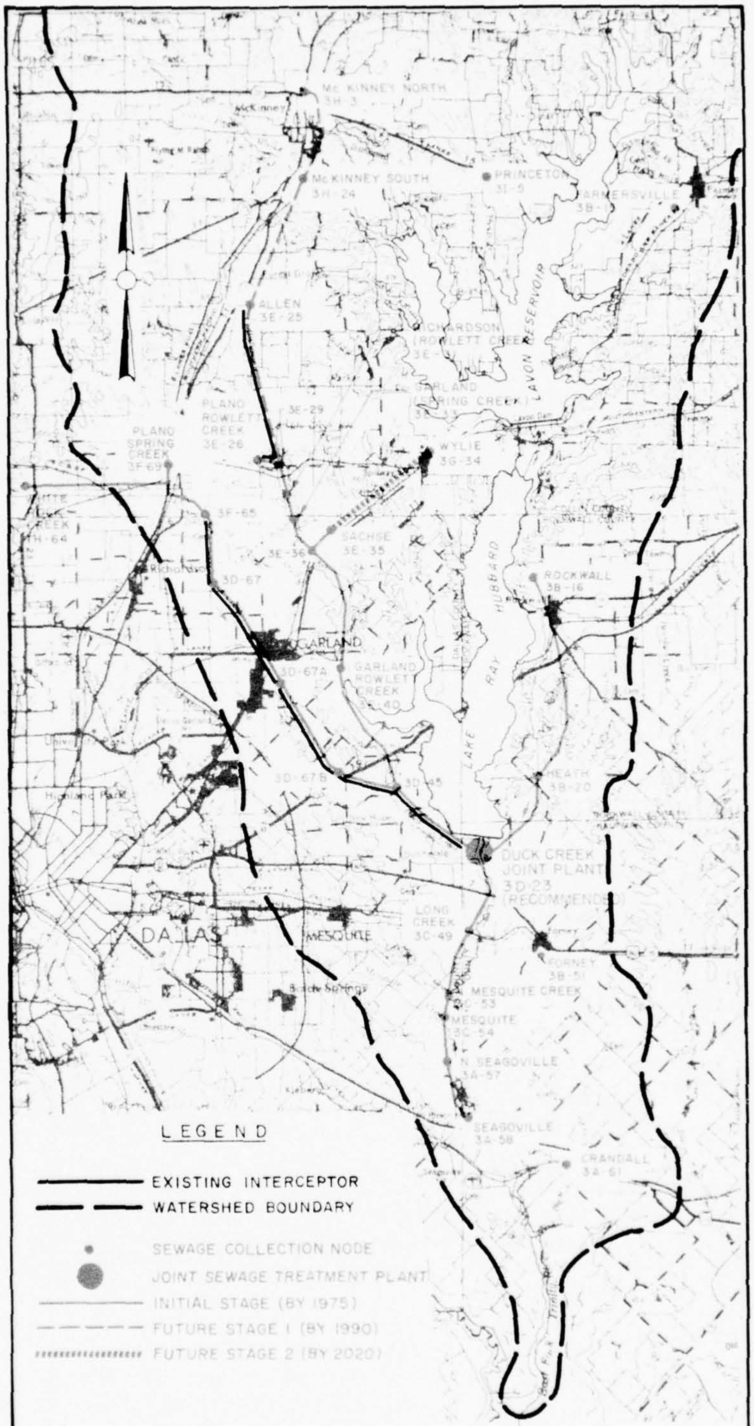


FIG. X-3 RECOMMENDED SEWERAGE SYSTEM (EAST FORK TRINITY - WATERSHED 3)

JULY, 1970

469 — 13855

TABLE X-6 POPULATION SERVED BY, FLOWS AND LOADS TO, JOINT PLANT

(Duck Creek Joint System)

	YEAR 1975	1990	2020
Duck Creek Joint Plant (Existing Capacity - 10.0 mgd) (3D-23)			
Population Served	274,160	773,800	1,075,000
Average Sewage Flow (mgd)	28.83	91.23	154.70
Average BOD Load (lb/day)	64,110	175,630	251,600
Average SS Load (lb/day)	68,440	197,740	281,100

TABLE X-7. RECOMMENDED INTERCEPTING SEWERS

(Duck Creek Joint System)

From Node	To Node	Interceptor Name	Length (l.f.)	Diameter (in)	Type of Interceptor
3H-3	3H-24	McKinney	14,400	24	Gravity
			11,500	12	Pressure
3H-24	3E-25	McKinney - Allen	3,000	30	Gravity
			30,000	36	Pressure
3E-25	3E-29	Allen-Plano Relief	36,400	42	Gravity
3E-26	3E-29	Rowlett-Plano	5,400	42	Gravity
3E-29	3E-36	Rowlett - Murphy	31,400	72-90	Gravity
3G-34	3E-36	Wylie - Sachse	9,200	24-30	Gravity
			15,600	24	Pressure
3E-36	3E-40	Rowlett - Garland	15,400	96	Gravity
			3,600	66	Pressure
3E-40	3D-45	Rowlett - Rose Hill	29,700	66	Pressure
1H-64	3F-69	Renner Road	19,600	30-36	Gravity
			15,200	36	Pressure
3F-69	3F-65	Spring Creek	13,400	48-60	Gravity
3F-65	3D-67	Jupiter Road Relief	5,800	42-48	Gravity
			5,400	48	Pressure
3D-67	3D-45	Duck Creek Relief	58,600	54-72	Gravity
3D-45	3D-23	Duck Creek Relief	22,000	102	Gravity
3B-16	3B-20	Lake Ray Hubbard East Shore	59,900	30	Pressure
3B-20	3D-23	Lake Ray Hubbard East Shore	12,600	36-42	Gravity
			9,000	30	Pressure
3A-58	3C-54	East Fork - Mesquite	13,000	36-42	Gravity
			8,400	36	Pressure

TABLE X-7. RECOMMENDED INTERCEPTING SEWERS

(Duck Creek Joint System)

(Continued)

From Node	To Node	Interceptor Name	Length (l.f.)	Diameter (in)	Type of Interceptor
3C-54	3D-23	East Fork - Mesquite	36,000	54	Pressure

Subtotals:

Gravity Interceptor Length:	260,200 l.f. (49 miles)
Pressure Interceptor Length:	224,300 l.f. (43 miles)
Total Length:	484,500 l.f. (92 miles)

Note:

Lengths are estimated from United States Geological Survey topographic maps of the study area (Scale 1:24,000).

TABLE X-8. STAGING AND CONSTRUCTION COSTS OF PROPOSED INTERCEPTING SEWERS(1)

(Duck Creek Joint System)

From Node	To Node	Interceptor Name	Initial (By 1975)	Future Stage 1 (By 1990)	Future Stage 2 (By 2020)
3H-3	3H-24	McKinney		$720,000	
3H-24	3E-25	McKinney - Allen		1,900,000	$560,000
3E-25	3E-29	Allen - Plano Relief		1,780,000	
3E-26	3E-29	Rowlett - Plano	$260,000		
3E-29	3E-36	Rowlett - Murphy	3,510,000		
3G-34	3E-35	Wylie			910,000
3E-35	3E-36	Sachse	170,000		
3E-36	3E-40	Rowlett - Garland	4,470,000		1,290,000
3E-40	3D-45	Rowlett - Rose Hill	5,690,000		1,410,000
1H-64	3F-69	Renner Road	1,940,000		360,000
3F-69	3F-65	Spring Creek	850,000		
3F-65	3D-67	Jupiter Road Relief	1,780,000		490,000
3D-67	3D-45	Duck Creek Relief	4,210,000		
3D-45	3D-23	Duck Creek Relief	3,970,000		
3B-16	3B-20	Lake Ray Hubbard East Shore	2,510,000		290,000
3B-20	3D-23	Lake Ray Hubbard East Shore	1,350,000		360,000

(1) Costs shown are for gravity interceptors, pressure interceptors, and pumping stations and are based on an ENR Construction Cost Index of 1100. Land costs are included.

TABLE X-8. STAGING AND CONSTRUCTION COSTS OF PROPOSED INTERCEPTING SEWERS(1)

(Duck Creek Joint System)
(Continued)

From Node	To Node	Interceptor Name	Initial (By 1975)	Future Stage 1 (By 1990)	Future Stage 2 (By 2020)
3A-58	3C-54	East Fork-Seagoville	$1,370,000		
3C-54	3D-23	East Fork-Mesquite	4,590,000		$1,770,000
		Subtotals	$36,670,000	$4,400,000	$7,440,000
		TOTAL			$48,510,000

TABLE X-9. SUMMARY OF PROJECT CONSTRUCTION AND OPERATION AND MAINTENANCE COSTS

(Duck Creek Joint System)

ITEM	ESTIMATED CONSTRUCTION COSTS(1)			
	INITIAL STAGE (By 1975)	FUTURE STAGE 1 (By 1990)	FUTURE STAGE 2 (By 2020)	TOTALS
Duck Creek Joint Treatment Plant	$37,930,000		$30,630,000	$68,560,000
Interceptors:				
Gravity	17,430,000	$2,320,000	130,000	19,880,000
Pressure	11,460,000	1,460,000	450,000	13,370,000
Pumping Stations	$ 7,780,000	$ 620,000	$ 6,860,000	15,260,000
TOTAL CONSTRUCTION COSTS	$74,600,000	$4,400,000	$38,070,000	$117,070,000

	ESTIMATED ANNUAL OPERATION AND MAINTENANCE COSTS		
	First Year (1975)	Average 1975-1990	Average 1990-2020
Duck Creek Joint Treatment Plant	$2,070,000	$3,870,000	$7,120,000
Interceptors:			
Gravity	$ 40,000	$ 50,000	$ 50,000
Pressure	$ 30,000	$ 30,000	$ 30,000
Pumping Stations	$ 140,000	$ 320,000	$ 780,000
SUBTOTALS	$2,280,000	$4,270,000	$7,980,000

Note: (1) Based on an ENR Construction Cost Index of 1100.

Land costs are included.

Rowlett Creek, 5,100 l. f. of gravity interceptor, is estimated to cost about $170,000. The existing Duck Creek Interceptor (3D-23 upstream to 3D-67) and Jupiter Road Interceptor (3D-67 upstream to 3F-65) should be paralleled and extended up Spring Creek to Plano (3F-69), thence west parallel to Renner Road to the White Rock Creek section of Plano (1H-64). The cost of 119,400 l.f. of gravity interceptors, 20,600 l.f. of pressure interceptors, and two pump stations is estimated to be about $12,750,000. Subsequent (Future Stage 2) expansion of the two pumping stations is estimated to cost about $850,000.

The Lake Ray Hubbard East Shore Interceptor, to extend from the Duck Creek Sewage Treatment Plant upstream to Heath (3B-20) and Rockwall (3B-16), is to comprise 12,600 l.f. of gravity interceptor, 68,900 l.f. of pressure interceptor, and two pumping stations, all estimated to cost about $3,860,000. Subsequent (Future Stage 2) expansion of the two pumping stations is estimated to cost about $650,000.

The East Fork Interceptor from Seagoville (3A-58) to Mesquite (3C-54), thence north to the Duck Creek Joint Plant (3D-23), comprising 13,000 l.f. of gravity interceptors, 44,400 l.f. of pressure interceptors, and three pumping stations, is estimated to cost $5,960,000. Subsequent (Future Stage 2) expansion of the three pumping stations is estimated to cost $1,770,000.

The proposed Initial Stage Program would permit early phasing out of plants at Plano, Garland-Rowlett Creek, Rockwall, and Seagoville, all judged inadequate in Table VIII-1. Coupled with local sewerage construction programs, construction of the Sachse and Lake Ray Hubbard East Shore Interceptors in the Initial Stage Program would permit early elimination of septic tank concentrations in Sachse and in waterfront areas near Heath, respectively.

Future Stage 1. It is proposed that the existing interceptor bringing flows to Plano (3E-29) from Allen (3E-25) be paralleled and extended north to McKinney (3H-24 and 3H-3) by 1990. The estimated cost of 53,800 l.f. of gravity interceptors, 41,500 l.f. of pressure interceptors, and two pumping stations is about $4,400,000. The proposed pumping station near the site of the existing McKinney North Sewage Treatment Plant is not expected to need expansion after 1990, inasmuch as there is no projected populated increase for node 3H-3. However, Future Stage 2 expansion of the pumping station near the site of the existing McKinney South Sewage Treatment Plant (3H-24) is estimated to cost about $560,000.

Table VIII-1 indicates that the two McKinney treatment plants were considered barely adequate or slightly inadequate in 1968. Therefore, it is recommended that construction of the Plano-Allen-McKinney interceptor be scheduled for shortly after 1975, for the existing plants are not expected to perform adequately for long after that date.

Future Stage 2. The capacity of the existing Wylie Sewage Treatment Plant will not be exceeded by projected flows until nearly 1990. It is therefore proposed that the Wylie Interceptor, from Wylie (3G-34) to Sachse (3E-35), be built shortly after 1990. The estimated cost of 4,100 l.f. of gravity interceptor, 15,600 l.f. of gravity interceptor, 15,600 l.f. of pressure interceptor, and one pumping station is about $910,000.

TRA CENTRAL JOINT SYSTEM

The joint sewerage system proposed for the Elm Fork and Lower West Fork of the Trinity River is shown on Figs. X-1 and X-4. Projected populations to be served by the TRA Central Sewage Treatment Plant, and projected flows and loads to this plant in 1975, 1990, and 2020, are presented in Table X-10. The proposed system of new and relief interceptors, totaling 111 miles, is described in Table X-11. Staging and estimated construction costs of the proposed interceptors is described in Table X-12. Construction and operation and maintenance costs for the joint system are summarized in Table X-13.

Separate treatment plants will continue to serve areas north of Lewisville and south of the proposed Lakeview Reservoir. The communities of Aubrey, Celina, Collinsville, Denton, Frisco, Gainesville, Gunter, Justin, Krum, Lake Dallas, Lindsay, Mansfield, Midlothian, Muenster, Pilot Point, Prosper, Roanoke, Sanger, Tioga, and Venus should retain and expand existing sewage treatment plants to provide at least secondary treatment initially, and advanced treatment by 1990. New separate treatment plants providing advanced treatment where feasible should be built in Argyle, Bolivar, Camp Copass, Leo, Myra, Rosston, Shady Shores, Valley View, and in future development around Grapevine Reservoir and south and east of the proposed Lakeview Reservoir.

Initial Stage. It is proposed that the existing TRA Central Sewage Treatment Plant (4A-166) be expanded by 1975 (Initial Stage) to provide tertiary treatment with a 1990 capacity of about 112 mgd, at an estimated construction cost of $40,480,000. Subsequent (Future Stage 2) expansion to a 2020 capacity of about 256 mgd is estimated to cost $56,070,000.

It is proposed in the Initial Stage of construction that the West Fork Interceptor be paralleled over its present length from Mountain Creek (5C-22) to Grand Prairie (5C-65), thence extended upstream past Arlington to the site of the Euless West Plant (5F-184). The cost of 74,800 l.f. of gravity relief interceptor, sized for 2020 flows, is estimated to cost about $13,290,000. No pumping stations or force mains are proposed for the West Fork Interceptor.

Initial Stage extension and relief of this interceptor will permit early phasing out of the Euless West and East treatment plants, and of the Arlington plant which are expected to be inadequate by 1975.

It is proposed that the Mountain Creek Interceptor from the TRA plant to Mountain Creek Lake be relieved and extended south to node 5C-208, thence west to node 5C-452, near Florence Hill, as shown on Fig. X-4. Construction of the 44,000 l.f. of gravity interceptor, 10,000 l. f. of force main, and construction and expansion of two pumping stations is scheduled for the Initial Stage and is estimated to cost $8,180,000. (Subsequent Future Stage 2 expansion of the two pumping stations to 2020 design capacities is estimated to cost $2,270,000.)

The interceptor from the Regional Airport (5A-19) to the existing Bear Creek Interceptor at node 5A-43 should be built in the Initial Stage to serve the airport, currently under construction. The estimated cost of this proposed gravity interceptor is estimated to be about $840,000. A short portion of the Elm Fork Interceptor, 3,000 l. f. of gravity trunk between 4A-124 and 4A-129, should be relieved by 1970. The estimated cost is about $600,000).

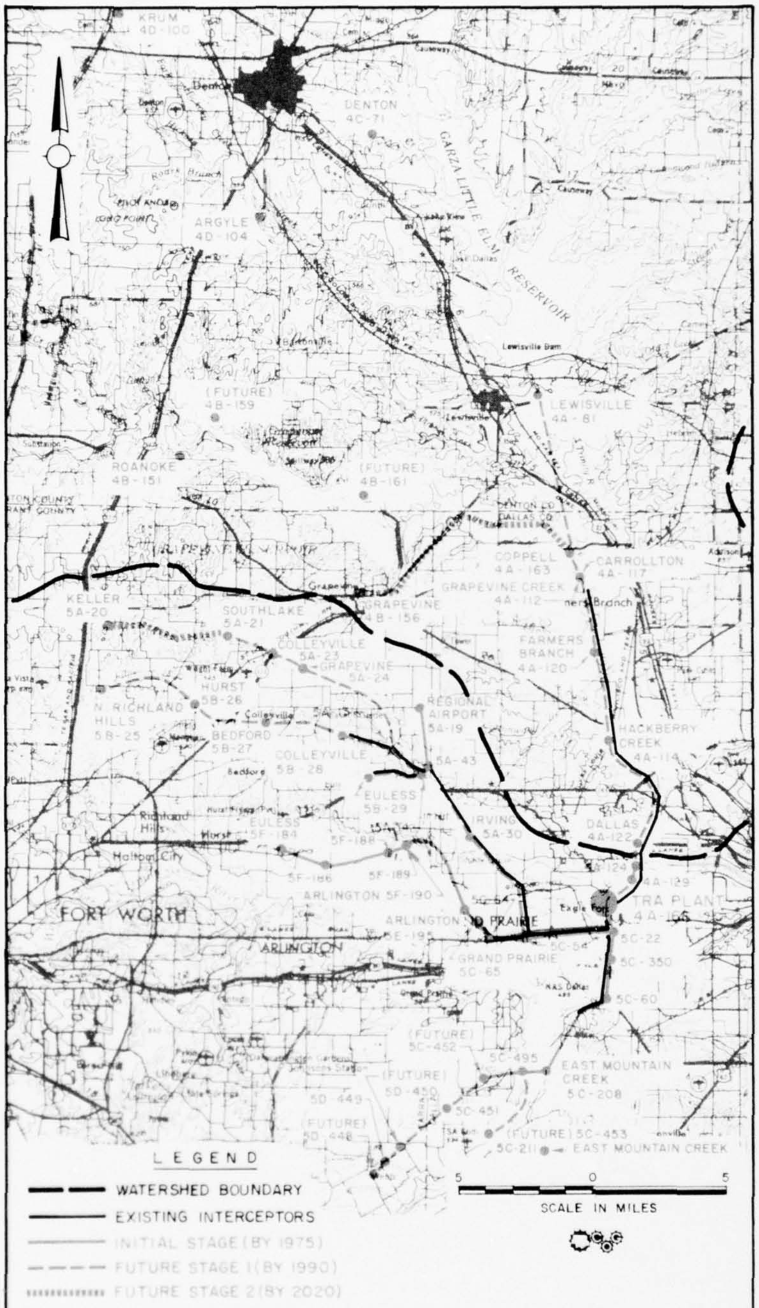


FIG. X-4 RECOMMENDED SEWERAGE SYSTEM
(TRA CENTRAL JOINT SYSTEM)

JULY, 1970

TABLE X- 10. POPULATION SERVED BY, FLOWS AND LOADS TO, JOINT PLANTS

(TRA Central Joint System)

	YEAR		
	1975	1990	2020
TRA Central Joint Plant (Existing Capacity - 30 mgd) (4A-166)			
Population Served	375,290	904,180	1,677,500
Average Sewage Flow (mgd)	40.54	111.88	256.04
Average BOD Load (lb/day)	91,230	226,210	454,600
Average SS Load (lb/day)	95,320	256,150	495,000

TABLE X-11. RECOMMENDED INTERCEPTING SEWERS

(TRA Central Joint System)

From Node	To Node	Interceptor Name	Length (l.f.)	Diameter (in)	Type of Interceptor
4A-81	4A-163	Lewisville-Coppell	39,000	42-66	Gravity
4B-156	4A-163	Denton Creek	63,600 3,000	30-54 36	Gravity Pressure
4A-163	4A-117	Elm Fork	5,000	78-84	Gravity
4A-117	4A-124	Elm Fork Relief	66,300	84-102	Gravity
4A-124	4A-129	Elm Fork Relief	3,000	108	Gravity
4A-129	4A-166	Elm Fork Relief	6,000	120	Gravity
5A-20	5A-21	Big Bear Creek	31,000	24	Gravity
5A-21	5A-13	Big Bear Creek	40,700	30-54	Gravity
5B-25	5B-28	Little Bear Creek	43,000	24-30	Gravity
5B-28	5A-13	Little Bear Creek Relief	8,000	30	Gravity
5A-13	5A-14	Bear Creek Relief	6,000	54	Gravity
5B-29	5A-14	Midway Park Creek Relief	14,000	24	Gravity
5A-14	5A-43	Bear Creek Relief	2,000	66	Gravity
5A-19	5A-43	Regional Airport	19,500	36	Gravity
5A-43	5C-54	Bear Creek Relief	48,500	60-84	Gravity
5F-184	5C-65	West Fork	48,300	60-108	Gravity
5C-65	5C-54	West Fork Relief	12,500	96-120	Gravity
5C-54	5C-22	West Fork Relief	14,000	132-150	Gravity
5D-448	5C-452	Webb	31,000 6,000	24-66 24-30	Gravity Pressure
5C-452	5C-208	Webb	10,000 7,000	78 54	Gravity Pressure

TABLE X-11. RECOMMENDED INTERCEPTING SEWERS

(TRA Central Joint System)
(Continued)

From Node	To Node	Interceptor Name	Length (l.f.)	Diameter (in)	Type of Interceptor
5C-453	5C-495	Lakeview Reservoir	21,000	48	Gravity
5C-208	5C-350	Mountain Creek Relief	24,000 3,000	66-90 54	Gravity Pressure
5C-350	5C-22	Mountain Creek Relief	7,000	72	Gravity
5C-22	4A-166	Mountain Creek Relief	3,000	180	Gravity

Subtotals:

Gravity Interceptor Length: 566,400 l.f. (107 miles)

Pressure Interceptor Length: 19,000 l.f. (4 miles)

Total Length: 585,400 l.f. (111 miles)

Note: Lengths are estimated from United States Geological Survey topographic maps of the study area (Scale 1:24000).

TABLE X-12. STAGING AND CONSTRUCTION COSTS OF PROPOSED INTERCEPTING SEWERS(1)

(TRA Central Joint System)

From Node	To Node	Interceptor Name	Initial Stage (By 1975)	Future Stage 1 (By 1990)	Future Stage 2 (By 2020)
4A-81	4A-163	Lewisville-Coppell		$2,610,000	
4B-156	4A-163	Denton Creek			$4,620,000
4A-163	4A-117	Elm Fork		310,000	
4A-117	4A-124	Elm Fork Relief		10,740,000	
4A-124	4A-129	Elm Fork Relief	$600,000		
4A-129	4A-166	Elm Fork Relief		1,400,000	
5A-20	5A-21	Big Bear Creek			930,000
5A-21	5A-13	Big Bear Creek		2,130,000	
5B-25	5B-28	Little Bear Creek		1,410,000	
5B-28	5A-13	Little Bear Creek Relief		270,000	
5A-13	5A-14	Bear Creek Relief		350,000	
5B-29	5A-14	Midway Park Creek Relief		420,000	
5A-14	5A-43	Bear Creek Relief		150,000	
5A-19	5A-43	Regional Airport	840,000		
5A-43	5C-54	Bear Creek Relief		4,630,000	
5F-184	5C-65	West Fork	6,800,000		
5C-65	5C-54	West Fork Relief	3,030,000		
5C-54	5C-22	West Fork Relief	3,460,000		
5D-448	5C-452	Webb		2,710,000	960,000
5C-452	5C-208	Webb	2,520,000		1,000,000
5C-453	5C-495	Lakeview Reservoir		1,080,000	
5C-208	5C-60	Mountain Creek	3,280,000		1,270,000
5C-60	5C-22	Mountain Creek Relief	1,390,000		
5C-22	4A-166	Mountain Creek Relief	990,000		
		Subtotals	$22,910,000	$28,210,000	$8,780,000
		TOTAL			$59,900,000

(1) Costs shown are for gravity interceptors, pressure interceptors, and pumping stations and are based on an ENR Construction Cost Index of 1100. Land costs are included.

Note: Lengths are estimated from United States Geological Survey topographical maps of the study area (Scale 1:24,000).

TABLE X-13. SUMMARY OF PROJECT CONSTRUCTION AND OPERATION AND MAINTENANCE COSTS

(TRA Central Joint System)

Item	ESTIMATED CONSTRUCTION COSTS[1] Initial Stage (By 1975)	Future Stage 1 (By 1990)	Future Stage 2 (By 2020)	Totals
TRA Central Joint Treatment Plant	$40,480,000		$56,070,000	$96,550,000
Interceptors:				
Gravity	20,200,000	$27,340,000	4,000,000	51,540,000
Pressure	880,000	200,000	120,000	1,200,000
Pumping Stations	1,830,000	670,000	4,660,000	7,160,000
TOTAL CONSTRUCTION COSTS	$63,390,000	$28,210,000	$64,850,000	$156,450,000

Item	ESTIMATED ANNUAL OPERATION AND MAINTENANCE COSTS First Year (1975)	Average 1975-1990	Average 1990-2020
TRA Central Joint Treatment Plant	$2,770,000	$4,740,000	$10,040,000
Interceptors:			
Gravity	50,000	120,000	130,000
Pressure	Nil	Nil	Nil
Pumping Stations	40,000	60,000	250,000
SUBTOTALS	$2,860,000	$4,920,000	$10,420,000

Note:

(1) Based on an ENR Construction Cost Index for Dallas of 1100. Land costs are included.

Future Stage 1. The capacity of the recently expanded Lewisville Sewage Treatment Plant will be exceeded before 1990. Therefore it is proposed that the Lewisville-Coppell Interceptor, the Elm Fork Interceptor from Coppell (4A-163) to Carrollton (4A-117), and the Elm Fork Relief Interceptor from Carrollton to the TRA Central Plant be constructed by 1990. No force mains or pumping stations are proposed. The cost of 116,300 l.f. of gravity interceptor, which excludes the 3,000 l.f. of relief interceptor proposed for the initial stage, is estimated at approximately $15,060,000.

In the Bear Creek watershed, it is proposed to relieve by 1990 the entire existing interceptor from its junction with the West Fork Interceptor (5C-54) upstream to Colleyville (5B-28) on Little Bear Creek, and to relieve the Midway Park Creek Interceptor (5A-14 to 5B-29). It is proposed to extend the interceptor up Little Bear Creek from Colleyville (5B-28) to North Richland Hills (5B-25) and to construct the Big Bear Creek Interceptor from the junction with Little Bear Creek (5A-13) upstream as far as Southlake (5A-21) by 1990, permitting the phasing out of the package sewage treatment plant at Grapevine (5A-24). The estimated cost of 162,200 l.f. of gravity interceptors is $9,360,000. No force mains or pumping stations are proposed. (As mentioned previously, the Regional Airport Interceptor is proposed for the Initial Stage).

It is proposed that the interceptors serving the developing area near the proposed Lakeview Reservoir, from 5C-495 to 5C-453 (TSA Gliderport) and from 5G-452 to 5D-448 (near the town of Webb) be built by 1990. Construction of 52,000 l.f. of gravity interceptor, 6,000 l.f. of force main, and two pumping stations is estimated to cost about $3,680,000. (Subsequent Future Stage expansion of the two pumping stations to 2020 capacities is estimated to cost $960,000).

Future Stage 2. It is proposed to construct the Denton Creek Interceptor from Coppell (4A-163) to Grapevine (4B-156) as the sewage treatment plant at Grapevine becomes overloaded, an occurrence expected sometime after 1990. Construction of 63,600 l.f. of gravity interceptor, 3,000 l.f. of force main, and two pumping stations is estimated to cost about $4,620,000.

Extension of the Big Bear Creek Interceptor from Southlake (5A-21) to Keller (5A-20) is proposed for Future Stage 2. No force mains or pumping stations are proposed. Construction costs of 31,000 l.f. of gravity mains is estimated at about $930,000.

FORT WORTH VILLAGE CREEK JOINT SYSTEM

The joint sewerage system proposed for the West Fork of the Trinity River upstream of Village Creek is shown on Fig. X-1 and X-5. Projected populations to be served by the Village Creek Sewage Treatment Plant, and projected flows and loads to this plant in 1975, 1990, and 2020, are presented in Table X-14. The proposed new and relief interceptors, totalling 92 miles, are isted in Table X-15. Staging and estimated construction costs of the proposed interceptors are described in Table X-16. Construction and operation and maintenance costs for the joint system are summarized in Table X-17.

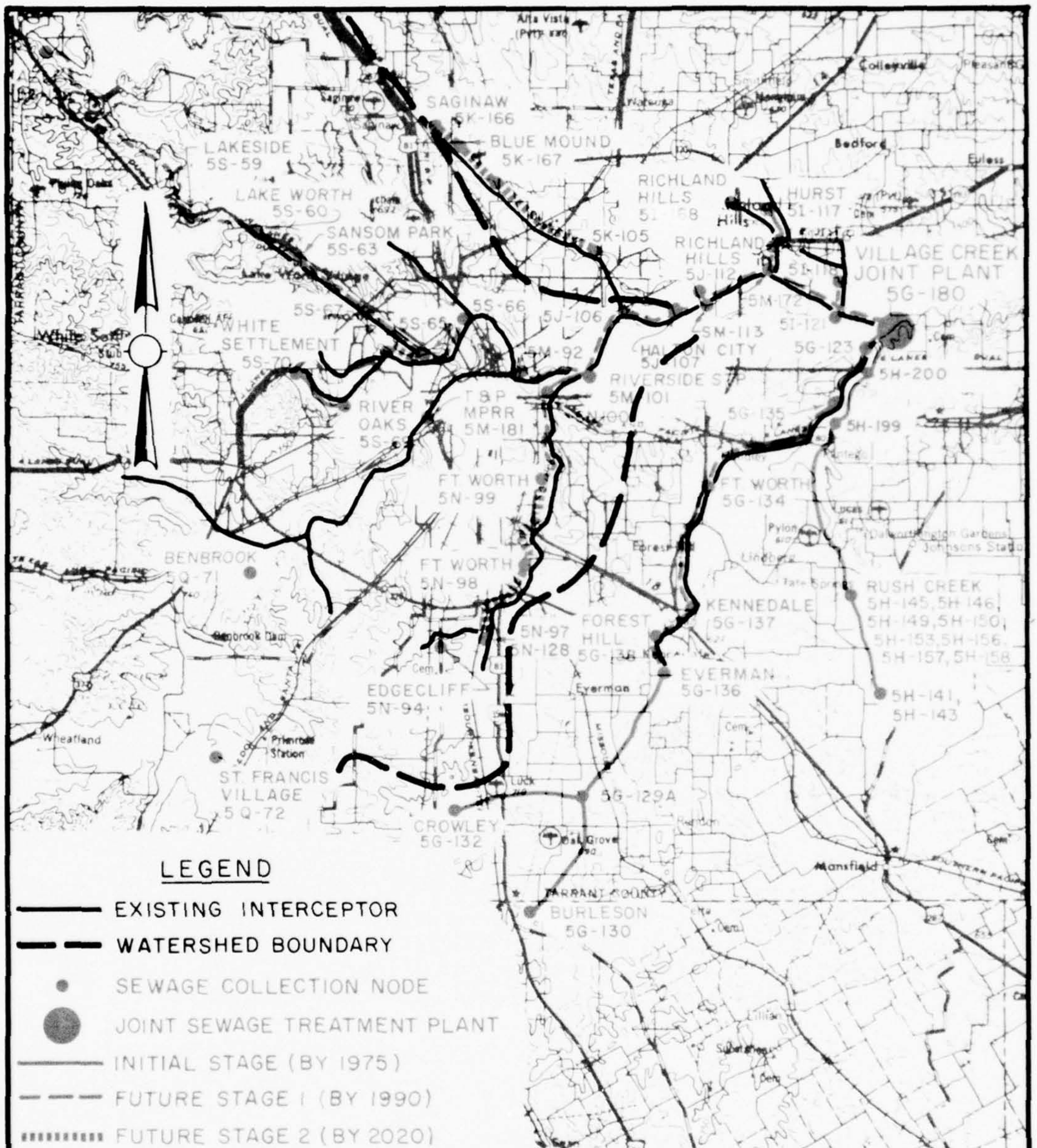


FIG. X-5 RECOMMENDED SEWERAGE SYSTEM (WEST FORK TRINITY - WATERSHED 5)

5 0 5
SCALE IN MILES

JULY, 1970

TABLE X-14. POPULATION SERVED BY, FLOWS AND LOADS TO, JOINT PLANT

(Village Creek Joint System)

	YEAR		
	1975	1990	2020
Village Creek Joint Plant (Existing Capacity - 45 mgd) (5G-180)			
Population Served	737,160	1,304,040	1,957,600
Average Sewage Flow (mgd)	79.55	165.58	298.84
Average BOD Load (lb/day)	185,620	338,840	546,800
Average SS Load (lb/day)	195,310	365,060	585,800

TABLE X-15. RECOMMENDED INTERCEPTING SEWERS

(Village Creek Joint System)

From Node	To Node	Interceptor Name	Length (l.f.)	Diameter (in)	Type of Interceptor
5S-175	5S-59	Jacksboro Highway - Azle	45,500 500	30-48 36	Gravity Pressure
5S-59	5S-60	Lake Worth Crossing	6,000	36	Pressure
5S-60	5S-65	Jacksboro Highway	25,000 11,400	24-60 42	Gravity Pressure
5S-70	5S-69	Westworth Relief	12,000	42	Gravity
5S-67	5S-65	Westworth Relief	5,000	36	Gravity
5S-65	5S-66	Westworth Relief	6,000	72	Gravity
5M-92	5M-101	West Fork Relief	13,000	90	Gravity
5N-97	5M-101	Sycamore Creek	46,000	36-108	Gravity
5M-101	5J-106	West Fork Relief	11,000	120	Gravity
5K-166	5J-106	Little Fossil Creek	33,000	24	Gravity
5J-106	5M-172	West Fork Relief	25,000	120	Gravity
5J-112	5M-113	Richland Hills	7,000	24	Gravity
5I-117	5M-172	Walker Calloway Relief	21,000	48-54	Gravity
5M-172	5I-121	West Fork Relief	9,000	108	Gravity
5I-118	5I-121	Hurst Relief	8,000	66	Gravity
5I-121	5G-180	West Fork	8,000	132	Gravity
5G-132	5G-129A	Crowley	21,000	24	Gravity
5G-130	5G-129A	Burleson	19,000	24	Gravity
5G-129A	5G-123	Village Creek	92,000	24-72	Gravity
5G-123	5G-180	Village Creek Relief	2,000	108	Gravity

TABLE X-15. RECOMMENDED INTERCEPTING SEWERS

(Village Creek Joint System)
(Continued)

From Node	To Node	Interceptor Name	Length (l.f.)	Diameter (in)	Type of Interceptor
5H-143	5G-180	Rush Creek	61,100	24-72	Gravity

Subtotals:

Gravity Interceptor Length	469,600 l.f. (89 miles)
Pressure Interceptor Length	17,900 l.f. (3 miles)
Total Length	487,500 l.f. (92 miles)

Note: Lengths are estimated from United States Geological Survey topographical maps of the study area (Scale 1:24,000).

TABLE X-16. STAGING AND CONSTRUCTION COSTS OF PROPOSED INTERCEPTING SEWERS(1)

(Village Creek Joint System)

From Node	To Node	Interceptor Name	Initial (By 1975)	Future Stage 1 (By 1990)	Future Stage 2 (By 2020)
5S-175	5S-59	Jacksboro Highway Azle		$2,480,000	$580,000
5S-59	5S-60	Lake Worth Crossing	$600,000		500,000
5S-60	5S-65	Jacksboro Highway Relief		2,330,000	800,000
5S-70	5S-69	Westworth Relief	580,000		
5S-69	5S-67	Westworth		(No relief necessary)	
5S-67	5S-65	Westworth Relief			210,000
5S-65	5S-66	Westworth Relief		530,000	
5S-66	5M-92	West Fork		(No relief necessary)	
5Q-71	5M-92	Clear Fork		(No relief necessary)	
5M-92	5M-101	West Fork Relief			
5N-94	5N-97	Edgecliff		(No relief necessary)	
5N-97	5N-99	Sycamore Creek Relief			1,290,000
5N-99	5N-100	Sycamore Creek Relief		700,000	
5N-100	5M-101	Sycamore Creek Relief	1,190,000		
5M-101	5J-106	West Fork Relief		2,560,000	

(1)Costs shown are for gravity interceptors, pressure interceptors, and pumping stations, and are based on an ENR Construction Cost Index of 1100. Land costs are included.

TABLE X-16. STAGING AND CONSTRUCTION COSTS OF PROPOSED INTERCEPTING SEWERS

(Village Creek Joint System)
(Continued)

From Node	To Node	Interceptor Name	Initial (By 1975)	Future Stage 1 (By 1990)	Future Stage 2 (By 2020)
5K-166	5K-105	Little Fossil Creek Relief			$990,000
5K-105	5J-106	Little Fossil Creek	(No relief necessary)		
5J-106	5M-172	West Fork Relief		$5,830,000	
5J-112	5M-113	Richland Hills	$210,000		
5I-168	5I-116		(No relief necessary)		
5I-117	5I-116	Walker-Calloway Relief	570,000		
5I-116	5M-172	Walker-Calloway Relief		590,000	
5M-172	5I-121	West Fork Relief		1,780,000	
5I-118	5I-121	Hurst Relief		630,000	
5I-121	5G-180	West Fork Relief		2,150,000	
5G-132	5G-129A	Crowley	630,000		
5G-130	5G-129A	Burleson	570,000		
5G-129A	5G-136	Village Creek	870,000		
5G-136	5G-123	Village Creek Relief		4,710,000	
5G-123	5G-180	Village Creek	360,000		
5H-143	5G-180	Rush Creek	3,380,000		
		Subtotals	$8,960,000	$26,100,000	$4,370,000
		Total			$39,430,000

TABLE X-17. SUMMARY OF PROJECT CONSTRUCTION AND OPERATION AND MAINTENANCE COSTS

(Village Creek Joint System)

Item	ESTIMATED CONSTRUCTION COSTS[1] Initial Stage (By 1975)	Future Stage 1 (By 1990)	Future Stage 2 (By 2020)	Totals
Village Creek Joint Treatment Plant	$53,950,000		$53,560,000	$107,510,000
Interceptors:				
Gravity	8,360,000	$25,030,000	2,490,000	35,880,000
Pressure	250,000	310,000		560,000
Pumping Stations	350,000	760,000	1,880,000	2,990,000
TOTAL CONSTRUCTION COSTS	$62,910,000	$26,100,000	$57,930,000	$146,940,000

Item	ESTIMATED ANNUAL OPERATION AND MAINTENANCE COSTS First Year (1975)	Average 1975-1990	Average 1990-2020
Village Creek Joint Treatment Plant	$4,910,000	$7,050,000	$12,200,000
Interceptors:			
Gravity	30,000	90,000	100,000
Pressure	Nil	Nil	Nil
Pumping Stations	10,000	30,000	100,000
SUBTOTALS	$4,950,000	$7,170,000	$12,400,000

Note:

(1) Based on an ENR Construction Cost Index of 1100.

Land costs are included.

It is proposed that separate treatment plants continue to serve areas north of Azle and west of Benbrook, as shown on Fig. X-1 appended to this volume and on Fig. X-5. Existing separate plants at Jacksboro, Bowie, Alvord, Chico, Bridgeport, Decatur, Boyd, Springtown, Weatherford, Aledo, Runaway Bay, and St. Francis Village should be retained. These plants should be expanded to accept greater flows and to provide adequate advanced treatment where feasible. New separate plants are proposed for Lake Amon G. Carter, Sunset, Park Springs, Wizard Wells, Jermyn, Paradise, Newark, Reno, and Lake Weatherford. Existing treatment plants at Azle, Benbrook, Haltom City, Hurst, Crowley, Burleson, Everman, Forest Hill, Kennedale, Richland Hills, Tarrant County WSC Plant No. 2., the mobile home parks in the Rush Creek basin, and the Fort Worth Riverside plant are to be phased out as the joint system is built.

Initial Stage. It is proposed that the existing Village Creek Sewage Treatment Plant (5G-180) be expanded by 1975 (Initial Stage) from its present secondary capacity of 45 mgd to provide advanced treatment with a 1990 capacity of about 166 mgd, at an estimated construction cost of $53,950,000. Subsequent (Future Stage 2) expansion to a 2020 capacity of about 299 mgd is estimated to cost about $53,560,000.

It is proposed to extend the existing Jacksboro Highway Interceptor by means of a pumping station and force main from its present upstream end at Lake Worth (5S-60), across a narrow section of Lake Worth to Lakeside (5S-59) to protect the lake from sewage effluent generated at Lakeside. The estimated construction cost of one pumping station and 6,000 l.f. of force main is about $600,000. (Subsequent Future Stage 2 expansion of the pumping station to 2020 capacity is estimated to cost $500,000). No gravity interceptor is proposed for this section.

For the Initial Stage it is proposed that the existing Village Creek Interceptor be extended upstream from Everman (5G-136) to Burleson (5G-130), with a branch extending westward to Crowley (5G-132). No pumping stations or force mains are proposed for this interceptor. Construction of the 63,500 l.f. of proposed gravity interceptor is estimated to cost about $2,070,000.

It is proposed that the communities of Wilson, Parson, Pantego, and Dalworthington Gardens, and several mobile home parks in the Rush Creek watershed, be served by the Rush Creek Interceptor by 1975. No pumping stations or force mains are proposed. Construction of the 61,100 l.f. of proposed gravity interceptors in this developing area is estimated to cost approximately $3,380,000.

Also proposed for Initial Stage construction are several relief interceptors: The Westworth Relief (5S-70 to 5S-69) 12,000 l.f. of gravity interceptor costing about $580,000; the Sycamore Creek Relief, 5N-100 to 5M-101, 6,000 l.f. of gravity interceptor estimated to cost about $1,190,000; the Walker-Calloway Relief, 5I-117 to 5I-116, 11,000 l.f. of gravity interceptor, estimated to cost about $570,000; and the Village Creek Relief Interceptor, 5G-123 to 5G-180, 2,000 l.f. of gravity interceptor estimated to cost $360,000. A 7,000 l.f. gravity interceptor, estimated to cost $210,000 (5J-112 to 5M-113) is scheduled in the Initial Stage to permit phasing out by 1975 of the Richland Hills (TCWSC No. 2) plant.

Future Stage 1. It is proposed that the Jacksboro Highway Interceptor be extended from Lakeside (5S-59) to Azle (5S-175) as the capacity of the Azle Treatment Plant operated by the TCWSD is exceeded, an occurance which is expected by 1990. The 45,500 l.f. of

gravity interceptor, one pumping station, and 500 l.f. of force main are estimated to cost about $2,480,000. (Subsequent Future Stage 2 expansion of the pumping station to 2020 capacity is estimated to cost about $580,000). Relief for the existing portion of the Jacksboro Highway Interceptor (5S-65 to 5S-60) is also proposed for Future Stage 1, and is estimated to cost about $2,330,000. These relief facilities consist of 25,000 l.f. of gravity interceptor, 11,400 l.f. of force main, and one pumping station. (Subsequent Future Stage 2 expansion of the pumping station to 2020 capacity is estimated to cost about $800,000).

Other interceptors proposed for Future Stage 1 are the Westworth Relief, 5S-65 to 5S-66, 6,000 l.f. of gravity interceptor estimated to cost about $530,000; the West Fork Relief, 5M-92 to 5M-101, 13,000 l.f. of gravity interceptor costing about $1,810,000; the Sycamore Creek Relief, 12,000 l.f. of gravity interceptor estimated to cost about $700,000; the West Fork Relief between the Riverside and Village Creek Treatment Plant 5M-101 to 5J-106, to 5M-172, to 5I-121, to 5G-180), 53,000 l.f. of gravity interceptor estimated to cost about $12,320,000; the Walker Calloway Relief, 5I-116 to 5M-172, 10,000 l.f. of gravity interceptor estimated to cost about $590,000; Hurst Relief, 5I-118 to 5I-121, 8,000 l.f. of gravity interceptor estimated to cost about $630,000; and the Village Creek Relief, 5G-136 (Everman) to 5G-123, 68,500 l.f. of gravity interceptor estimated to cost about $4,710,000.

Future Stage 2. Proposed for construction after 1990 but before 2020 are the Westworth Relief Interceptor, 5S-67 to 5S-65 (junction with the Jacksboro Highway Interceptor), 5,000 l.f. of gravity interceptor estimated to cost about $210,000; the Sycamore Creek Relief Interceptor, 5N-97 to 5N-99, 28,000 l.f. of gravity interceptor costing about $1,290,000; and the Little Fossil Creek Relief, 5K-166 (Saginaw) to 5K-105, 33,000 l.f. of gravity interceptor estimated to cost about $990,000.

As shown in Table X-16, several existing interceptors in the Village Creek Joint System have capacities adequate for projected 2020 flows and hence are expected to need no relief before the year 2020.

CHAMBERS CREEK - WAXAHACHIE CREEK WATERSHEDS 10 & 11

It is recommended that the 7 local treatment plants serving Alvarado, Maypearl, Grandview, Italy, Milford, Waxahachie, and Ennis be retained as necessary. Staging of expansion of these treatment plants is shown in Table X-19, to be discussed presently. It is recommended that adequate treatment including advanced treatment where feasible, be provided to all wastewater tributary to Lake Waxahachie and to Bardwell Reservoir, to avoid pollution and eutrophication of those lakes.

WATERSHEDS 6, 7, 8, 9, and 12

As noted in Chapter IX, Watersheds 6, 7, 8, and 9 are sparsely populated, with no significant population increase projected for the future. Hence, no joint collection systems are considered economically feasible. In Watershed 12, composed of those parts of Collin, Rockwall, and Kaufman Counties tributary to the Sabine River, the major population center is Royse City. A local plant capable of adequate treatment of Royse City sewage is recommended for the protection of Lake Tawakoni. Construction costs of this plant are indicated in Table X-19 (to be discussed hereinafter), as the only costs shown for Watershed 12 (Sabine River).

GENERAL RECOMMENDATIONS

Six joint sewerage systems are proposed as principal components of the recommended regional sewerage plan. Secondary treatment facilities which now either exist or are under construction at the sites of the six joint treatment plants should be expanded and advanced treatment facilities provided as necessary to meet future requirements. In addition, the proposed joint systems will include about 351 miles of intercepting sewers (both gravity and pressure) and 24 pumping stations. As shown in Table X-18, 46 existing treatment plants will be phased out.

The recommended regional plan includes an additional 79 treatment plants which are proposed to remain separate from the joint systems and be expanded as local conditions dictate, plus 25 separate new plants which will be required in the future. Advanced treatment facilities should be provided whenever feasible at these plants. Such treatment is especially important in the area tributary to water supply reservoirs.

Estimated construction costs (1970 costs) for joint systems and separate local treatment plants are shown in Table X-19 for the twelve watersheds in the study area. Costs are indicated for Initial Stage, Future Stage 1, or Future Stage 2 construction, as presented heretofore in this report. Future Stage 1 costs are further presented for construction expected to be required by 1980, 1985, or 1990. (Allocation of costs to different staging periods is based on existing plant capacities shown in Table IV-1, projected population and flow data presented in Tables V-3 and V-6, design criteria set forth in Chapter VI, and linear interpolation where required. While values presented in Table X-19 provide guidelines for long-range regional planning, required construction in any particular area at any particular stage can be accurately determined only by a more detailed study).

As shown in Table X-19, the total cost for contruction of the joint systems through 2020 is estimated to be $576,670,000, or about $570,000 per mgd of joint treatment plant capacity provided.The total construction cost for all plants outside of the areas served by proposed joint systems is estimated to be $123,460,000. The estimated total construction cost of all facilities proposed herein; i.e. joint systems plus separate plants, is about $700,130,000.

Project costs are plotted on Fig. X-6. Estimated annual operation and maintenance costs for the joint systems are expected to average $26,750,000 through 1990 as shown in Table X-20.

The general recommendations as to the degree of treatment provided are dependent on water quality objectives. The treatment processes proposed are those which reflect the latest advances in sewage treatment plant technology. A number of advanced waste treatment processes may be employed (as discussed in Chapter XI) with similar degrees of success depending upon the results of specific pilot plant studies. Such studies should be considered as a part of the detailed design of any major treatment facility.

It is recommended that induced river aeration be considered in conjunction with other methods of treatment to increase D.O. levels and satisfy BOD requirements of receiving streams (as discussed in Chapter XI). At the present time the use of instream

TABLE X-18. PROPOSED DISPOSITION OF EXISTING SEWAGE TREATMENT PLANTS

I. Six Plants to be Expanded into Joint Treatment Plants

Node No.	Name or Location	Node No.	Name or Location
1D-161	Ten Mile Creek	4A-166	TRA Central
1F-146	Dallas - South Side	3D-23	Duck Creek
1I-175	Dallas - White Rock	5G-180	Village Creek

II. Forty-Six Plants to be Phased Out*

Node No.	Name or Location	Node No.	Name or Location
Trinity River - Watershed 1			
1D-145	Wilmer	1E-150	Seagoville Fed. Corr. Inst.
1E-147	Kleberg	1G-143	Hutchins
1E-149	Balch Springs (Dallas-Hickory Tree WCID #6)	1H-66	Richardson - Floyd Branch
East Fork Trinity - Watershed 3			
3A-58	Seagoville	3E-40	Garland - Rowlett Creek
3B-16	Rockwall	3G-34	Wylie
3C-54	Mesquite	3H-3	McKinney - North
3E-26	Plano	3H-24	McKinney - South
Elm Fork Trinity - Watershed 4			
4A-81	Lewisville	4B-156	Grapevine
		4B-170	Green Acres Estates
Big Bear Creek and Little Bear Creek - Watersheds 5A and 5B			
5A-20	Keller (N.Tarrant Co.M.W.D.)	5A-60	Greenview Addition
5A-24	Grapevine	5B-170	Green Valley Mobile Home Park (Smithfield)
Watersheds 5C, 5D, 5E, 5F			
5E-195	Arlington	5F-188	Euless (East)
5F-184	Euless (West)	5F-189	Greater Southwest Airport

*Construction of proposed facilities will determine phase-out date.

TABLE X-18. PROPOSED DISPOSITION OF EXISTING SEWAGE TREATMENT PLANTS (Continued)

II. Forty-Six Plants to be Phased Out (Continued)

Node No.	Name or Location	Node No.	Name or Location
West Fork Trinity - Watershed 5			
5G-130	Burleson	5H-159	Poly-Webb Mobile Home Park
5G-132	Crowley	5J-17	Keller Mobile Home Park
5G-133	Sunny Acres Mobile Home Park (Crowley)	5J-107	Haltom City
5G-136	Everman	5J-112	Richland Hills (TCWSC #2)
5G-137	Kennedale	5M-101	Fort Worth - Riverside
5G-138	Forest Hill	5M-172	TCWSC #1 (Highway 820)
5H-141	Banfield Mobile Home Park	5Q-71	Benbrook
5H-143	Royal Coach Mobile Home Park	5S-59	Lakeside
5H-145	L & M Mobile Home Park	5S-175	Azle (TCWSC)
5H-150	Treetop (South) Mobile Home Park		
5H-153	Tumbleweed Mobile Home Park		
5H-156	Wilson Mobile Home Park		

TABLE X-19. ESTIMATED COSTS FOR RECOMMENDED CONSTRUCTION AND EXPANSION

Area	J* or S	1975	FUTURE STAGE 1 1980	1985	1990	Total	FUTURE STAGE 2 2020	Grand Total
WATERSHED 1								
Dallas - White Rock	J	44,630	1,830	-	-	1,830	29,470	75,930
South Side	J	23,150	-	-	-	-	21,540	44,690
Ten Mile Creek	J	-	18,450	-	-	18,450	17,140	35,590
Southeast Area	S	4,820	800	-	-	800	8,900	14,520
WATERSHED 2								
Cedar Creek	S	4,880	960	550	410	1,920	10,400	17,200
WATERSHED 3								
Duck Creek	J	74,600	4,400	-	-	4,400	38,070	117,070
East Fork Trinity	S	1,790	-	-	1,640	1,640	2,770	6,200
WATERSHEDS 4, 5								
TRA Central	J	63,390	25,450	2,760	-	28,210	64,850	156,450
Elm, Lower West Forks	S	10,440	4,210	-	280	4,490	28,970	43,900
WATERSHED 5								
Village Creek	J	62,910	22,570	2,240	1,290	26,100	57,930	146,940
Upper West Fork	S	9,640	120	-	-	120	10,560	20,320
WATERSHED 6								
Brazos River, Parker Co.	S	-	-	-	-	-	-	-
WATERSHED 7								
Brazos River, Johnson Co.	S	-	-	-	-	-	-	-
WATERSHED 8								
Nolands River	S	-	900	900	900	2,700	2,600	5,300
WATERSHED 9								
Richland Creek	S	-	-	-	-	-	-	-
WATERSHEDS 10, 11								
Chambers Creek, Waxahachie Creek	S	5,800	-	-	240	240	7,570	13,610
WATERSHED 12								
Sabine River	S	-	-	-	1,030	1,030	1,380	2,410
TOTAL	J	268,680	72,700	5,000	1,290	78,990	229,000	576,670
	S	37,370	6,990	1,450	4,500	12,940	73,150	123,460
GRAND TOTAL		306,050	79,690	6,450	5,790	91,930	302,150	700,130

*J = Joint
S = Separate

NOTE: All costs are 1970 estimates in thousands of dollars. Land costs are included.

TABLE X-20. SUMMARY OF PROJECT OPERATION AND MAINTENANCE COSTS(1)

	ESTIMATED ANNUAL OPERATION AND MAINTENANCE COSTS(1)		
	First Year 1975	Average 1975-1990	Average 1990-2020
WATERSHED 1			
Dallas - White Rock Plant	$5,750,000	$6,990,000	$9,400,000
Dallas - South Side	1,900,000	2,430,000	4,010,000
Ten Mile Creek	200,000	970,000	2,210,000
WATERSHED 3			
Duck Creek	2,280,000	4,270,000	7,980,000
WATERSHEDS 4, 5			
TRA Central	2,860,000	4,920,000	10,420,000
WATERSHED 5			
Village Creek	4,950,000	7,170,000	12,400,000
TOTAL	$17,940,000	$26,750,000	$46,420,000

Note:

(1) All joint systems only.

aeration in The Trinity River and its tributaries in the study area does not appear feasible because of extreme flow variations, but if dams and locks are constructed as part of the canalization project, the feasibility should be reevaluated.

Low flow augmentation is not recommended as a means of achieving water quality objectives in the Upper Trinity River Basin. Nutrients in treatment plant effluents and surface runoff indicate the need for advanced treatment to prevent the eutrophication of lakes and reservoirs.

Infiltration of storm water into sewage collection systems should be controlled as discussed in Chapter III. In the absence of effective control measures, storm water chlorination detention tanks (in addition to treatment plants) may be required to prevent water quality impairment during wet weather periods. Such tanks may be provided either at treatment plant sites or at principal points of overflow upstream. When constructed, they should be of sufficient capacity to provide settling and chlorine contact for all over-flow from trunk sewers.

Any sewage treatment plant, regardless of the degree of treatment provided, should be constructed to function at design capacity during maximum anticipated river stages. Plants should be located either on sufficiently high ground or equipped with sufficient effluent pumping capacity to function properly at such times. Sludge resulting from sewage treatment processes should be disposed of in such a manner that it will have no deleterious effect upon the water, air or land environment and present no health hazard.

Facilities proposed as part of the recommended regional sewerage plan are based on the criteria and conditions indicated. In any area subject to an unanticipated influx of population or industry as from a major development, adjustments in the sewerage facilities proposed herein may be necessary. If the population of the study area or a watershed grows more rapidly than anticipated, consolidation of joint treatment facilities and construction of interceptors may be justified at a more rapid rate than indicated by the proposed staging.

These recommendations should constitute a basis of comparison to enable NCTCOG to evaluate the suitability of sewerage construction projects proposed by others where such projects are at variance with those proposed herein.

CHAPTER XI

TREATMENT AND DISPOSAL OF WASTES

The water pollution control standards recently established in Texas require, in many cases, higher degrees of wastewater treatment than provided by conventional processes. Conventional treatment processes are described in Chapter VI. Furthermore, those standards necessitate greater control of water in sludge and solid waste disposal areas than has generally been achieved in the past.

The achievement of pollution abatement and water reclamation in the North Central Texas region requires knowledge of the processes available and the economics involved in their selection. Therefore, in this section are presented reviews of the reclamation and reuse of wastewater, advanced wastewater treatment processes and the treatment and disposal as its practice may affect the quality of surface and groundwaters in the study area.

The processes discussed herein are by necessity those which reflect the current state of technological development. The projection of trends of future technological development in water pollution control is in its infancy. However, trends appear to be generally in the direction of more efficient and compact means of removing objectionable substances from water, more acceptable or beneficial methods of sludge disposal and greater automation.

RECLAMATION AND REUSE OF WASTEWATER

Discussion of the reclamation and reuse of wastewater in the study area requires the consideration of relevant factors pertaining to the quantity and quality of water needed. The implementation of a policy of reclamation and reuse would affect the location of and the type of treatment needed at sewage treatment plants as well as the future water supply needs of the area. The reuse of reclaimed water for electric power plant cooling water is a major consideration.

RATIONALE

The supply of natural fresh water on the Earth, and in any geographical area, is relatively fixed over a long period of time. In any specific location, to be sure, there are wet years and dry years, wet cycles and dry cycles; but over a long span of time the fresh-water supply from rainfall is relatively constant.

Furthermore, this Earth has the same water now that existed in prehistoric days. Except for some relatively insignificant chemical combinations and changes in form, water is neither created not destroyed by nature. It repeatedly has been used, contaminated, purified by nature's hydrologic cycle, and reused.

The idea of reutilization of wastewater, without benefit of the hydrologic cycle, is not novel either in concept, in reality, or in public recognition and acceptance. Such reutilization has been occurring for years along the major rivers of the U.S., where many cities and large industries take water from the river, and return their wastewater

to the river for subsequent use by downstream entities. On the Trinity River this same situation exists, with the Dallas-Fort Worth metropolitan area discharging wastewater which eventually reaches Livingston Reservoir which supplies water to Houston. Construction of the Tennessee Colony Reservoir will also cause this type of reutilization to take place.

Purification of water prior to municipal use has long been standard practice. In recent years treatment of the returned wastewater has also become mandatory inasmuch as natural stream self-purification has become increasingly inadequate to protect multiple beneficial uses deemed suitable for the water.

An indirect reuse of domestic wastewater also occurs in areas replete with septic tanks and leaching drain fields. With such systems, liquid wastewaters percolate through the soil and eventually replenish the groundwater supply. The distribution of septic tank and other subsurface disposal systems in the study area is discussed in Chapter IV.

Undiluted but highly treated municipal wastewater has also been used for recreational lakes (including swimming areas), for irrigation of crops and grazing land, and for many industrial purposes, as described later in this section. The ultimate in wastewater renovation and reutilization will occur soon in prolonged space flights and at lunar colonies where human liquid wastes will have to be used again for human consumption after purification by evaporative processes followed by carbon adsorption.

Despite its potential value, no one cherishes the thought of using treated wastewater for any purpose. However, when pristine or previously unused water ceases to be available and plentiful, or when it must be imported great distances at high cost, the rationale for wastewater renovation and reutilization becomes more acceptable, especially in relation to beneficial uses where water quality requirements are not too stringent. It is evident, therefore, that the feasibility of wastewater reuse in any region must be evaluated on the basis of all local conditions and factors.

In assessing the feasibility and desirability of wastewater reclamation in North Central Texas, it is reasonable to inquire:

1. What is the need for supplemental water supplies, now and in the foreseeable future?

2. In what manner can wastewater best be conserved and reused in this region?

3. What are the potential markets for renovated wastewater?

4. What are the criteria of water quality for such beneficial uses?

5. What policy of wastewater reclamation is recommended for North Central Texas?

These questions are considered in the following discussion.

THE NEED FOR SUPPLEMENTAL WATER

At present the supply of fresh water for the study area, including imported supply from the adjacent Sabine River watershed, appears to be adequate for municipal, recreational, industrial, and agricultural demands, as reported in the Texas Water Plan. Indeed, with continued maintenance of existing systems, extended distribution, and planned water works expansion, the natural supply of fresh water in the Upper Trinity River basin should be adequate to meet anticipated population growth and industrial expansion for about 20 years (to 1990). Thereafter, according to the Texas Water Plan, the Upper Trinity River basin will need an imported supplemental supply increasing to about 350,000 acre ft per year by year 2020 even with allowances for the reuse of return flows downstream from Dallas and Fort Worth.

The Water Plan indicates that supplemental water may not be needed in the North Central Texas region for about 20 years. However, cooling water requirements for the rapidly growing electric power industry in the region will probably involve reuse much sooner. It is prudent, therefore, for water supply and wastewater authorities to plan now for eventual reuse of the wastewater and to develop through research and demonstration plants the optimum techniques and design to produce polished effluent of the necessary quality. Such a plant is presently in operation at the Dallas Wastewater Reclamation Center.

There is another facet of overall water management in North Central Texas that adds credence to the feasibility of wastewater reuse in this region. The Texas Water Quality Requirements (as of October 1967), discussed in Chapter III, are such that a high degree of wastewater treatment must be provided for all sewage before discharge to the Trinity River and its tributaries. For example, dissolved oxygen (D.O.) concentration in the Trinity River downstream from Dallas is restricted to a minimum of 4.0 mg/1. Present concentrations are frequently less than this limit, especially during dry summer months. Sewage treatment and low flow augmentation requirements to meet a D. O. concentration of 4.0 mg/1 are discussed in Chapter X. For water-contact recreational areas the geometric mean concentration of fecal coliform bacteria is limited to 200 per 100 ml. Thus, a high degree of disinfection is indicated.

These water quality requirements are not likely to be relaxed or their enforcement waived. Indeed, the trend in Texas and nationwide has been toward even stricter standards. To meet them will require a high degree of very reliable biological secondary treatment and/or advanced wastewater treatment as discussed in Chapters IX and X. Higher degrees of treatment will be required by the construction of the Trinity River canalization project with its multiple locks, deeper water, and relatively quiescent pools. When it becomes necessary to provide tertiary or advanced treatment to wastewater, even for discharge to the river, the quality of such effluent may be suitable for several categories of reuse, as described later in this section. For example, it may be feasible for Dallas, Fort Worth or other cities to sell such high-grade wastewater to industry for at least one reuse before eventual discharge to the Trinity River.

CATEGORIES OF POSSIBLE REUSE

The reutilization of treated wastewater may be "indirect or direct". Implementation of either category requires the thorough prior consideration of water hygiene to assure

that reuse does not lead to the spread of disease. Indirect utilization is considered to occur where treated wastewater loses its identity by dilution, blending, and/or natural treatment. It takes place when return flows to rivers such as the Trinity River are diluted and later reused by downstream entities. Indirect reutilization also occurs as a result of groundwater recharge from such sources as septic tank drainage and effluents from wastewater treatment plants which are discharged to land for infiltration into pervious soil and percolation to groundwater basins. Here the effluent is subjected to a very high degree of natural treatment and quickly loses its identity by blending with natural groundwater.

Direct reutilization of treated wastewater (municipal and industrial) is a frequent practice in Texas and throughout the arid regions of the U.S. Among the major direct uses being practiced are (a) irrigation of crops, grazing land, greenbelts, parks, golf courses, and cemeteries, (b) recreational lakes for boating, fishing, and even bathing, (c) industrial process water, and (d) industrial cooling water, especially for steam-electric power plants.

In a few rare instances, to date, treated sewage has been used in a quasi-direct manner for municipal water supply. A classic example of such use occurred at Chanute, Kansas in 1956, as described by Metzler et al. The Texas Water Plan notes that "Renovation of municipal and industrial wastewaters for direct municipal reuse presently is technically feasible and may be economically practical in the future. In Texas, as elsewhere throughout the nation, extensive reuse for such purposes is improbable in the near future". The North Central Texas region has an extensive system of water storage reservoirs which in general is expected to be adequate to meet municipal water supply needs through 1990. Thereafter, reuse for domestic purposes is expected to be needed. In general, therefore, there appears to be no need to consider direct reuse for municipal water supply in this region. However, other direct uses as well as indirect methods of reuse are worthy of consideration and are discussed below. The applicability of these and other methods for the treatment, per se, of wastewater is discussed later in this Chapter under "Advanced Waste Treatment".

Groundwater Recharge. Wastewater that has received sufficient pretreatment may be added to the natural groundwater supplies:

(a) By intermittent spreading on natural soil or artificial sand beds.

(b) By sprinkler irrigation of crops or woodland, and

(c) By direct injection into recharge wells. This latter method is applicable where the presence of an aquaclude prevents percolation from the surface into a suitable groundwater basin or aquifer.

Intermittent percolation from a spreading basin normally is to be preferred to pressurized injection into a confined aquifer. Intermittent percolation provides a high degree of aeration that promotes oxidation of carbonaceous organic matter and ammonia nitrogen. In contrast, the only oxygen available to injected water is that which is already dissolved in such water prior to injection. Furthermore, intermittent percolation will generally work quite effectively even when the water being spread contains pinpoint activated sludge floc or moderate concentrations of algae. These substances will rapidly clog an injection well and hence they must be removed by controlled filtration before injection.

The rate at which a good activated sludge effluent can be spread on a natural soil bed, day after day and month after month for many years without extensive resting or repairs, is a function of the soil characteristics (median grain size and geometric deviation), soil chemistry, depth to groundwater, the organic content of the effluent, and the frequency, duration, and depth of application. With a highly stabilized activated sludge effluent, an average hydraulic loading rate of 1.0 ft per day, with the surface of the bed being dry for more than 12 hours each day, was sustained by McMichael and McKee at Whittier Narrows through an agricultural soil.

The soils near the Fort Worth and Dallas sewage treatment plants, however, do not appear to be nearly so amenable to surface spreading and intermittent percolation into groundwater basins or aquifers. The generalized soil map (Fig. IV-3) shows these soils to be dark brown to dark gray crumbly calcareous clay at the surface, 10 to 40 inches thick, over dark gray firm calcareous clay. It is unlikely that such soils could sustain an average hydraulic loading and subsequent percolation of even 0.1 ft per day, which is equivalent to 0.1 acre ft per acre per day or 32,600 gallons per acre per day.

At a loading of 0.1 ft per day, approximately 3,000 acres (4.7sq mi) of spreading basins would be needed now for intermittent percolation at Dallas and about 1,800 acres (2.8 sq mi) at Fort Worth. Future area requirements would be proportionately higher as flows increase. The purchase of such extensive acreage and its maintenance with respect to weed growth and mosquito control would be costly and the location of large spreading basins near population centers would be undesirable.

Even if, through graded sand topped with pea gravel and coarse rocks, a high rate of infiltration could be achieved, the subsurface geology in this part of Texas does not lend itself to ground water recharge and subsequent recovery for municipal, industrial, or agricultural water supply. The Trinity Group and Woodbine Aquifers, which underlie much of North Central Texas, are relatively tight and not conducive to wells of large specific capacity (gpm per ft of drawdown). Although many of these aquifers were once artesian, the total availability of water from them has been very small, compared with surface supplies. In 1965, for example, only about 4.3 percent of the Dallas water supply came from groundwater, and water levels in such wells were generally 300 to 1,000 ft below the surface.

Thus, intermittent percolation does not appear feasible in North Central Texas as a means of groundwater recharge.

Sprinkler irrigation has been used successfully for disposal of some industrial wastes (e.g. by the Campbell Soup Company at Paris, Texas, and at Sumter, South Carolina), and for seasonal wastes at State and Federal forest camps. In most instances, primary or secondary effluent is sprinkled over cultivated or forested land with the expectation that part of the water will evaporate, part will be transpired by the vegetation and the remainder will percolate into the soil or perhaps be purified by slow overland surface run-off.

The best rate of application ever recorded, which involved sprinkling in a heavily forested area, was 100 ft per year, or about 3.25-in per day. At Paris, Texas, the rate of application was only 0.25-in per day, or about 7.5 ft per year. Sprinkler irrigation has been used primarily as a means for effluent disposal and not for groundwater recharge

or wastewater reuse. For groundwater recharge, it is generally less effective than intermittent sand or soil percolation and may, therefore, be considered not feasible in the North Central Texas area.

Direct injection of treated sewage through pressurized recharge wells into deep pervious strata has been practiced by the Los Angeles County Flood Control District and other agencies in California to establish fresh-water barriers against salt-water intrusion in coastal areas. Direct injection of oil-field brines has also been practiced extensively in Texas under the supervision of the Texas Railroad Commission. Limited disposal of liquid wastes, other than that from oil or gas production, has been regulated by the Texas Water Development Board under a stringent permit system. No major injections of either category of liquid wastes have taken place in the North Central Texas area to the best of our knowledge.

Direct injection has several inherent advantages over intermittent spreading and sprinkler irrigation; but also some serious drawbacks. Among the favorable factors are the minimal surface area requirements, the freedom from extensive grading and earth moving, the absence of possible odors, and the unobtrusive appearance of injection structures above ground in contrast with spreading basins. Disadvantages include the necessity for sand or diatomite filtration, chlorination, and other possible pretreatment before injections, the absence of any mechanism for maintenance of aerobiosis after a soil-water contact and the necessity for cleaning and redeveloping the recharge wells periodically. As with sprinkler irrigation, recharge wells have been used primarily as means of waste disposal and not as a mechanism for wastewater recovery and reuse. If practiced within the North Central Texas region direct recharge would be subject to the severe capacity limitations imposed by the Trinity Group and Woodbine Aquifers as discussed above. The U.S. Geological Survey has recently started a research program on deep well disposal of wastes to determine what effect such disposal may have on the underground environment and to assess the level of risk.

In summary, groundwater recharge by any of the methods described above does not appear feasible in North Central Texas for large-scale water renovation and reuse.

Agricultural Irrigation. As noted in the Texas Water Plan, the "use of municipal effluents for irrigation is an accepted practice in many parts of the United States and is also practiced in Texas, particularly in the western part of the State. A survey of 1,200 Texas cities, conducted by Texas Technological College for the Board, indicated that part or all of the sewage effluent from 135 towns and cities in the State was being used for irrigation of an agricultural crop in 1965". This practice is carefully regulated by the Texas State Department of Health.

Irrigation with treated sewage has been practiced in the United States primarily for the water content, as a substitute for scarce natural waters or sparse rainfall in arid areas. In many other more humid parts of the world municipal effluents have been used for irrigation largely as a source of nitrogen, phosphorus, and other nutrient substances.

With average annual rainfall of about 34-in per year, North Central Texas generally has had little need for irrigation even by natural waters, except during years of severe drought. Unless and until a demand for extensive irrigation with surface or groundwaters develops, there will be no large market for waste water, as an economic

substitute for natural irrigation water. Small wastewater irrigation projects may be expected to develop in isolated local areas when the feasibility is apparent, and when high quality treated wastewater becomes available. However irrigation on a large scale does not appear applicable in North Central Texas as a method of wastewater reclamation and reuse.

Recreational Lakes. In arid areas remote from natural surface waters, the use of highly treated sewage for recreational lakes has proved to be popular, especially from the viewpoint of public relations. The most publicized example has been Santee, California, where disinfected polished effluent is used in lakes for boating, fishing, and even bathing, with a high degree of public acceptance.

Fortunately, North Central Texas is blessed with numerous impoundments of natural surface water, many of which are available for recreational use. There appears to be no need, therefore, to create artifical lakes of sewage effluent for recreation. In severe droughts, however, it may be desirable to pump some highly treated municipal effluent into certain impoundments to maintain water levels, as discussed under "Cooling Water" below. Such maintenance of water levels would have recreational advantages, but may lead to serious problems of accelerated eutrophication. Eutrophication is discussed in Chapter III.

Industrial Process Water. The reutilization of wastewater by industry may be divided into two categories, (a) the in-plant recycling and reuse of industrial waters, and (b) the purchase and use of adequately treated municipal wastewater. Process water is considered to include all waters required in production operations but not including cooling waters.

The first category, in-plant recirculation, is very common in Texas, especially in the manufacture of paper, petroleum products, rubber and plastic, lumber and wood products, natural gas products, and many others as reported in Table II-3 of the Texas Water Plan. As an example of water conservation from reuse, the national average water requirement for manufacturing a ton of steel is 65,000 gal, but by the recirculation and treatment of industrial effluents, the Kaiser Steel plant at Fontana,California, requires only 4,000 gal per ton. Such recirculation diminishes total water demand and promotes conservation of valuable fresh-water supplies.

The second catergory, use of municipal wastewater for industrial processes (other than cooling water and boiler feed water), has had limited application, owing largely to strict water quality requirements for direct process water. A prime example of such use occurs in Maryland where the Bethlehem Steel Company purchases the well-oxidized activated sludge effluent from the city of Baltimore and uses if for numerous operations in steel production. At several locations in Texas (e.g. Odessa, Amarillo, Big Spring) municipal effluents have been used for secondary oil recovery, as well as for cooling and boiler feed water.

The industrial market for the use of municipal effluents as process waters in North Central Texas will, at best, be very limited, for two reasons; (a) there are not now, nor are there likely soon to be, many large water-using industries such as petrochemical plants, refineries, pulp and paper mills, tanneries, etc., in this area, and (b) most industries likely to locate in this area, such as food-processing, electronic manufacturing, and electroplating plants require process water of very high quality.

The present use of water (from both municipal and well supplies) by all industries in both the Dallas-Fort Worth area (other than for steam-electric power production) is only about ten per cent of the discharge of municipal effluents from these cities. Thus, it is evident that the industrial processes inherent to the economy of North Central Texas are not likely to become large markets for reclaimed water.

Cooling Water. Many industrial operations involve the dissipation of excess heat. This thermal adjustment is generally accomplished by transfer of the heat through cooling coils to circulating water. Where water is abundant, it is circulated only once through the cooling coils, then discharged to a stream, lake, or ocean. When natural water is scarce, it is recirculated, frequently through a circuit of heat-transfer coils and cooling towers which release the heat to the atmosphere.

In areas of water scarcity, the largest industrial use of reclaimed wastewater, by far, has been for cooling. In Texas, municipal effluents at Big Spring, Amarillo, and Odessa have been used as cooling water at refineries and petrochemical plants. A similar market is not apparent in the study area because there are no major refineries, and none have been announced for the foreseeable future. The largest refinery in the study area is the Fort Worth Refining Company which uses about 0.55 mgd of which 80 percent is obtained from wells. Inventory data on this refinery are in Appendix C.

A much larger potential industrial user, however, exists in the steam-electric power industry. The demand for electric power in the North Central Texas region is doubling every seven years, and the need for cooling water may be expected to keep pace. As discussed below, the use of treated wastewater by the steam-electric power industry in the study area is considered feasible from the standpoints of both availability of water for cooling and potential market for the water.

ELECTRIC POWER PLANT UTILIZATION

With the exception of a few relatively small municipal plants (e.g. Denton,Garland, Greenville, Commerce), all electric-utility power in North Central Texas is generated and distributed by three operating companies which are subsidiaries of the Texas Utilities Company. The operating entities are (a) Dallas Power Light Company, which serves Dallas and some suburban areas, all in Dallas County, (b) Texas Electric Services Company which serves Tarrant County and 46 other counties of north-central and west Texas, and (c) Texas Power and Light Company which serves areas north, east, and south of Dallas, embracing a total of 52 counties. The three systems are interconnected at several points with each other and with the Houston Lighting and Power Company.

Table XI-1 presents data relative to the steam-electric power plants in or near the NCTCOG area, with a brief description of the sources of cooling water. Of the eleven plants listed, seven with a combined generating capacity of 4,472.6 megawatts of installed electrical capacity (MWe), utilize impounded water as a source of cooling water and as a heat dissipator for returned water. The other four plants with a combined generating capacity of 834.7 MWe have cooling towers, for which the make-up water is pumped from deep wells in theTrinity Sands aquifers.

Cooling water requirements for the eleven power plants have been estimated at about 56 mgd based on the present utilization of cooling towers (16 percent) and lakes (84 percent) as indicated in Table XI-1. Representatives of the Dallas Power & Light Company, Texas Electric Service Company and Texas Power & Light Company have

TABLE XI-1. STEAM-ELECTRIC POWER PLANTS IN OR NEAR STUDY AREA (1969)

Company	Name of Plant	Installed Capacity MWe	Source and Description of Cooling Water	Remarks
Dallas Power & Light Company	Dallas Central	223.5	Wells in Trinity Sands, 2,800 ft deep with cooling towers	Older plant
	Mountain Creek	955.5	Mountain Creek Lake	
	Parkdale	327.0	White Rock Creek	Also uses Wells in Trinity Sands, 3,300 ft deep with cooling towers
	North Lake	700.0	North Lake, plus purchase of 5,000 AF/year	
	Lake Hubbard	375.0	Lake Ray Hubbard	Lake water also used for municipal water supply
	Subtotal	2,581.0		
Texas Electric Service Company	North Main	130.0	Wells and cooling towers	Older plant in Ft. Worth
	Eagle Mountain	290.0	Eagle Mountain Lake	375 MWe expansion under construction
	Handley	567.0	Lake Arlington	Potential conflict with municipal water supply
	Subtotal	987.0		
Texas Power & Light Company	Collin	154.2	Wells in Trinity Sands, 600 ft deep with cooling towers	
	Trinidad*	435.1	Small lake, make-up from Trinity River	May have to use cooling towers if more capacity added
	Subtotal	589.3		
Joint Ownership (above companies)	Big Brown*	1,150.0	Big Brown Creek Reservoir	Under construction
Municipal plants (Denton, Garland, Greenville, etc.)	--	250.0	---	---
	Total	5,557.3		

* Outside NCTCOG area

furnished information from which the table was prepared. Within ten years water requirements are expected to more than double as a result of increased power needs and the greater proportion of cooling accomplished with cooling towers. By the year 2020, water requirements, based on existing cooling technology, will become a major problem for the power industry.

Inasmuch as most of the capacity at the Trinidad and Big Brown plants will be available for use within the NCTCOG area, the total installed generating capacity in 1970 for steam-electric power will be about 5,550 MWe as shown in Table XI-1 if other tie-ins are disregarded. If the power demand continues to increase at a rate of 10.6 percent per year, the total demand by the year 1990 will be:

$$5550\,(1.106)^{20} = 41{,}600 \text{ MWe}$$

On this basis it would be necessary by 1990 to construct new plants with a total capacity of 36,000 MWe, or perhaps even more as older plants become obsolescent, to serve the NCTCOG area. Some of these plants, to be sure, may be located outside of the North Central Texas area, but for economic reasons much of the new capacity will probably be constructed within this area.

Finding sufficient cooling water for all of the required new capacity will not be an easy task. Most of the available reservoir sites for surface cooling have been utilized or preempted. Furthermore, supplies from groundwater are severely limited. Finally, it is unlikely that pristine water from municipal supplies will be available for cooling tower make-up. It is logical, therefore, to consider locating new power plants in the vicinity of municipal wastewater facilities so that high quality effluent can be used for cooling towers.

How much of the water resources of North Central Texas can be conserved if wastewater effluent is used for all of the 36,000 MWe of new electrical capacity? At 24,000 gpd per MWe for cooling tower make-up water and a 50 percent average load factor, the water requirement would be 432 mgd, or 484,000 acre ft per year. This quantity is greater than the 350,000 acre ft of supplemental supply needed by the year 2020, as estimated in the Texas Water Plan. Moveover, about one-fourth of the makeup water will be available as return water from cooling tower blow-down. It appears, therefore, that the effective use of municipal wastewater by the power industry might preclude the need for imported supplementary water supply for this purpose.

For once-through cooling water restricted to a temperature rise of 10°C,the water requirement averages about 1,000,000 gpd per MWe. When cooling towers are used, about 24,000 gpd per MWe (1.0 gallon per KW hour) is required for evaporative losses and blow-down to prevent salt accumulation. If the cooling water is recirculated through lakes to provide natural surface cooling, the loss by evaporation is only about 8,000 gpd per MWe in North Central Texas. The actual water loss, of course, will depend on the load factor and in most cases will be about half of the foregoing figures on a megawatt-hour basis.

Some of the impoundments listed on Table XI-1 serve also as sources of municipal water supply. A thorough description of existing reservoirs is presented in Chapter II. During normal or wet years, when surface water supplies are adequate, these lakes can be kept nearly full, so that there is no conflict of interest between utility and municipal uses. But during dry years or droughts, the draw-down of a reservoir for

municipal demand will place severe restrictions on cooling water service, both by lowering the water surface elevation and by decreasing the surface area needed for evaporative cooling (about one acre per megawatt production). In fact, some of the lakes and tributary drainage areas (e.g. Mountain Creek and Trinidad Plants) are sufficient for present needs but may require make-up water from other sources when additional capacity is added.

The electric power utility companies in North Central Texas have already given preliminary consideration to the use of well-treated municipal effluents, especially as make-up water for cooling towers. The city of Denton now has plans for using sewage effluent for the operation of its municipal power plant. Conceivably, effluent from the Dallas municipal wastewater plant could be used at the Dallas Central power station, and/or at the Parkdale plant, in lieu of deep well water from limited aquifers. Effluent might also be used during droughts to supplement the natural run-off into surface impoundments that are not used for municipal water supply, (e.g. Mountain Creek Lake), but this practice would lead to concomitant problems of accelerated eutrophication.

As indicated above, many new electric power plants will have to be built in the next decade. Whether they derive heat from fossil fuels or nuclear fission, they will need condenser cooling water in great quantities. With a limit to the availability of natural reservoir sites, and with competition for their use by growing municipal demands, the electric power industry should surely give serious attention to the direct use of well-treated municipal wastewater for cooling tower make-up.

Advantages. It might be to the mutual benefit of both the power industry and the municipalities for new electric power plants *to be located adjacent to municipal* sewage treatment plants. The power plants might take make-up water from tertiary treatment lagoons or holding ponds, and discharge blow-down water back to the municipal treatment plant or the river, as shown on Fig. XI-1.

The slightly elevated temperature of the blow-down water, when returned to the treatment plant, will undoubtedly be beneficial to biological treatment processes, by accelerating the rate mechanisms. In addition, back pressure steam from the power plant might be used to evaporate a portion of the municipal wastewater to produce mineral-free water that would have many potential uses. The power companies might also be interested in surplus digester gas for operation of gas turbines during peak loads.

Advantages may be expected to accrue to both the electric power plant industry and municipalities through utilization of treated wastewater for cooling water.

Advantages to Power Plant Industry are:

1. Consistent availability of cooling water for power plant in sufficiently great quantities.

2. Location of cooling water source near power demand centers.

3. Permit future power plant expansion unlimited by potential shortage of cooling water.

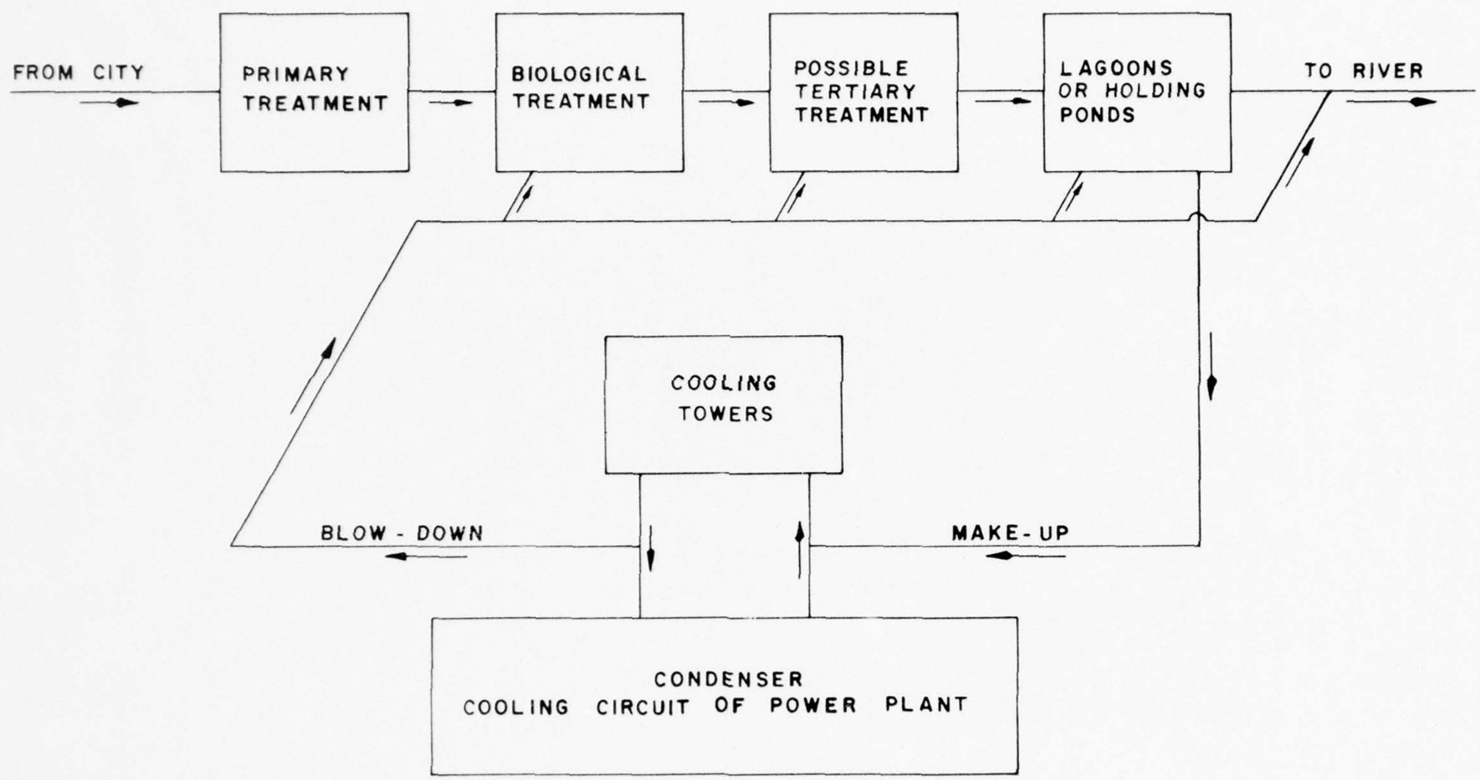


FIG. XI-1 TREATED WASTEWATER COOLING WATER SCHEMATIC DIAGRAM

Advantages to Municipalities are:

1. Ready market for treated wastewater with significant revenue possible from its sale.

2. Availability of electric power in large quantities.

3. Elevated temperature of blow-down water will benefit biological processes.

Consider a hypothetical population of 500,000 discharging a mean annual wastewater flow of 50 mgd. This population in North Central Texas would require at present an installed electrical generating capacity of about 1.8 KW per capita, with a load factor of about 55 percent, i.e. a 900 MWe plant is needed, but its average output would be only about 500 MWe. The average flow of water through the condenser cooling circuit of the power plant would have to be about 500 mgd if the temperature increment is limited to 10°C (18°F), which is standard for most steam turbine systems. It would be impractical to circulate all of this 500 mgd flow through a 50 mgd wastewater treatment plant, so cooling towers would be indicated. Such cooling towers could function with a little as 12 mgd make-up water on the average, or about 22 mgd during peak operation, and the design of treatment plants should include these flows when appropriate. Cost estimates for treatment plants proposed in this report do not however include allowances for cooling water return flows.

How much should this hypothetical city charge the power plant for an average flow of 12 mgd of adequately treated wastewater? How much is the power plant justified in paying? Quite obviously, the wastewater should be sold at a price that reflects equitably the benefits and costs to the city and power plant. The price that the power plant is likely to pay will depend upon an evaluation of alternative sources of cooling water, the added cost of cooling towers and their operation, and the cost of disposal of blow-down water.

If the power plant purchased cooling tower make-up water from the municipal supplies of Dallas or Fort Worth, the present industrial-commercial water rate would be 33¢ per 1,000 gal; however, this is high quality domestic water. At Amarillo, as shown hereinafter, adequately-treated wastewater is sold to a power company for a reported 18¢ per 1,000 gal; at Los Alamos the use of treated wastewater in lieu of well water represents a saving of a least 20¢ per 1,000 gal; at Burbank the saving is estimated at 4¢ per 1,000 gal; and near Las Vegas, Nevada, the purchase price is 3¢ per 1,000 gal. For North Central Texas, therefore, it would appear that the equitable price for good secondary effluent might be about 10¢ per 1,000 gal at the treatment plant site, with all costs for transmission and further treatment to be borne by the power company. For highly treated effluent, the price might justifiably be higher.

The estimated potential revenue to be derived from the sale of treated wastewater from treatment plants proposed as part of the recommended regional sewerage system (see Chapter X) is shown in Table XI-2.

TABLE XI-2. POTENTIAL REVENUE FROM SALE OF TREATED EFFLUENT

Sewage Treatment Plant

Node	Name	Average (1) Flow (mgd)	Annual (2) Revenue
1D-161	TRA Ten Mile Creek	16.46	$ 144,000
1E-146	Dallas-South Side	43.17	378,000
1I-175	Dallas-White Rock	139.70	1,224,000
3D-23	Duck Creek	91.23	799,000
4A-166	Trinity River Authority	111.88	978,000
5G-180	Village Creek	163.38	1,430,000
	TOTALS	565.82	$4,953,000

Notes: (1) 1990 plant design flow.

(2) Based on 10¢ per 1,000 gal, assuming 24 per cent of effluent sold for cooling water.

Quality and Costs of Cooling Water. The use of adequately-treated municipal effluent for cooling water may possibly be viewed with apprehension by some engineers and chemists in the power industry who may suspect that increased concentrations of organic nutrients, calcium phosphate, detergents, and total ionic strength will lead to added problems of microbiological fouling, scale formation, foaming and corrosion. Experience at several installations during the past decade or longer, however, has shown that municipal wastewater can be used for condenser cooling circuits with fewer problems and lower costs than when well water or another pristine supply is used.

Municipal effluent has been used successfully for condenser cooling water at commercial steam-electric plants at Amarillo,Texas; Los Alamos, New Mexico; Dennison, Texas; Las Vegas, Nevada; Richmond, Indiana; Lansdale, Pennsylvania;and Burbank, California. Such effluent has also been used for cooling towers of petroleum, natural gas, and petrochemical plants at Odessa, Big Springs, Amarillo,Corpus Christi and El Paso, Texas, and Enid and Duncan, Oklahoma. The following discussion is confined to the commercial power plant experience at Amarillo, Los Alamos, LasVegas, and Burbank, where extensive experience and records are available; but

before any similar large-scale use of municipal effluent in North Central Texas is planned in detail, the information from the petroleum industry should also be reviewed thoroughly.

The Nichols Station of the Southwestern Public Service Company near Amarillo,Texas uses part of the City's activated-sludge effluent. The reclaimed water is conveyed six miles through an 18-in cement-lined steel pipe to the power station. There the wastewater is subjected to cold lime-alum treatment for reduction of phosphates, magnesium, and silica. Orthophosphates are decreased from about 40 mg/l in the wastewater to about 1.0 mg/l in the cooling tower make-up water, but reconcentrated to 3.0 mg/l in the cooling water system. Robinson and Terry maintain that removal of orthophosphates is essential to prevent formation of insoluble calcium phosphate scale. This observation is not confirmed by experience at Los Alamos and Burbank, as described below. At the Nichols Station, sulfuric acid is added to bring the pH down to 7.8 at the cooling towers, partly to minimize delignification of the redwood towers and partly to control precipitation of calcium carbonate in the condenser circuit. Heavy dosages of chlorine are applied intermittently to control biological fouling. Corrosion rates are no higher than at other plants using natural water. Foam is no problem. It is suppressed by falling droplets in the cooling towers. Now that detergents are biodegradable, their concentration in the activated sludge effluent seldom exceeds 1.0 mg/l. Robinson reports that the total cost for the initial unit of 1.2 mgd, including amortization of the 6-mile pipeline and local lime treatment plant, amounted in 1960 to 22¢ per1,000 gal ($70/acre ft). When the plant is expanded to a contemplated 6 mgd, the cost per acre foot will be considerably less.It is understood that reclaimed water is now sold to the power company at the rate of 18¢ per 1,000 gal.

Cold lime treatment is also used at the Clark and Sunrise Stations of the Nevada Power Company near Las Vegas, to treat the effluent from a trickling filter plant of Clark County Sanitation District. The lime treatment lowers the orthophosphates from about 35 mg/l to less than 1.0 mg/l, and it also provides a reduction in silica varying from 20 to 60 percent. Various coagulant aids have been tried to supplement the lime treatment, but as of May 1966 no satisfactory additive had been found. At the cooling towers, sulfuric acid is added to maintain the pH in the range of 7.2 to 7.5. Chlorine is added continuously to maintain a residual of 1.0 mg/l, but in addition a heavy shock dosage is applied once per week. As at Amarillo, foaming has not been a problem. The Nevada Power Company has a contract with the Sanitation District for a guaranteed quantity of water at $30.00 per million gal (about $10 per acre ft or 3¢ per 1,000 gal). The cost of treatment at the power station was not disclosed.

At Los Alamos, the Zia Corporation is a contractor to the Atomic Energy Commission for operation and maintenance of the water, gas, electric, and sewage systems. The water obtained from deep wells is costly (28¢ per 1,000 gal for operation and maintenance alone) and the supply is limited. Hence, conservation of water resources is essential. Sewage is treated in a standard-rate trickling filter plant from which about 0.3 mgd of effluent has been used since 1951 for cooling tower make-up at the steam electric plant. The only treatment provided at the power plant has been heavy routine chlorination plus occasional shock loadings, pH adjustment, and the addition of polyphosphate, chromate, and zinc for corrosion control. No attempt is made to remove phosphates, magnesium, silica, or turbidity from the trickling filter effluent.

Even with concentration factors of 4 to 5 and the high levels of phosphate and silica shown above, scale formation had been so slight that it was not necessary to acid-clean the condensers in the 34 months that this operation was used. With the pH at 6.4, delignification of the cooling towers has been almost non-existent. There have been no problems for odors, flies or other insects, or foaming. Algal growths were troublesome for a while until the operators learned to control such growths by intermittent drying of selected cooling towers. Humphreys estimates the saving to the Zia Corporation, by using treated sewage rather than well water, to be 20¢ per 1,000 gal (or about $65 per acre ft).

Information about the Burbank situation has not yet been published, but Mr. J.D. Woodburn of the Public Service Department has furnished the following data. The Public Works Department operates an activated-sludge plant designed for 6.0 mgd. Part of the effluent flows through a short pipeline to the City-owned steam-electric power plant (169 MWe capacity). The cooling towers receive condenser circulating water (about 116,000 gpm) at 96°F and cool it to 80°F. The make-up effluent water to the towers is determined by the heat loading and evaporation. It averages 1.0 gal per KWH (24,000 per MWe) with reclaimed wastewater, but it was only 0.73 gal per KWH when softened well water was used formerly. Blow-down is about 25 per cent of the make-up. Normally the concentration factor is about 4 to 1 and it is controlled automatically by conductivity measurements. When concentrations get too high, the rate of blowdown is increased, and the rate of make-up automatically rises also. In August 1969 the make-up averaged 2.36 mgd.

As at Los Alamos, no effort is made to remove phosphates, which average about 35 mg/l in the municipal effluent and 120-140 mg/l in the cooling circuit. Sulfuric acid is added automatically to keep the pH at 6.5. At this acid reaction, calcium phosphate does not precipitate and form scale; but a dispersant polyelectrolyte is also added to minimize any possibility of scale formation. At this low pH, delignification of the redwood cooling towers is no longer the serious problem that it was when softened high-pH well water was used. Chlorine is added daily for about an hour to build up to a residual of 1.0 to 1.5 mg/l. This daily dosage controls microbiological fouling. Once each day, a cup of anti-foaming agent is added as insurance against foam, which has not been troublesome in any event. It has been estimated that the savings to the City by using reclaimed wastewater is approximately $13.50 per acre ft (4¢ per 1,000 gal). In the foregoing four examples, two power plants used lime treatment for removal of phosphates while two controlled phosphate scale formation and delignification by lowering the pH value. Both methods of control have advantages and disadvantages. The optimum system of quality control for future plants in the NCTCOG area will have to be determined for each municipal effluent that may be used for cooling tower makeup.

CONCLUSIONS AND RECOMMENDATIONS

The reclamation and reutilization of municipal wastewater in North Central Texas represents a potential means for increasing the total water resources of the area. Although supplies of fresh water are generally adequate for present municipal uses, additional imported water will probably be needed by about 1990. A more urgent need for additional water appears to be developing in the electric power generating industry. It is prudent,therefore, to explore and develop ways by which existing water resources can be conserved by reclamation and reuse of wastewater.

The rationale for reuse is enhanced by the fact that new water quality requirements in the Trinity River system will necessitate a high degree of treatment of municipal wastewater plants, just for discharge to surface streams. The effluents from these plants should be suitable for several forms of direct and indirect reutilization with little or no additional treatment.

Among the classical forms of renovation and reuse, groundwater recharge by spreading, sprinkling, or direct injection is precluded by a tight clay soil mantle and by unfavorable geological formations of pervious aquifers. Agricultural irrigation does not loom as a sizable market for wastewater. Existing and future recreational lakes in the study area can be replenished adequately with natural fresh water, except during severe droughts. The discharge of reclaimed waters into such lakes for replenishment might lead to serious problems of accelerated eutrophication but should be given consideration. Process industries in this area are not likely to require or want large quantities of renovated municipal wastewater, although some small uses may develop.

The largest potential market, by far, for adequately-treated municipal effluent appears to be the steam-electric power industry. Within the next decade the generating capacity for electric power in North Central Texas will have to be more than doubled to meet increasing demand. Adequate supplies of condenser cooling water for such expansion will be difficult to obtain and assure. New large power stations might advantageously be located adjacent to municipal wastewater treatment plants, to utilize treated effluent as makeup water for cooling towers. The locations of treatment plants proposed for inclusion in the recommended regional sewerage plan for the North Central Texas study area are shown on Fig. X-1. Experience elsewhere has shown that adequately-treated wastewater can be used for cooling tower make-up with a minimum of trouble with a considerable saving in overall cost, and with conservation of pristine water for other uses.

After 1990, depending on the success of plans to import needed water at that time (Texas Water Plan), the direct reuse of municipal wastewaters for domestic purposes may become a necessity.

The valuable assistance and comments obtained from members of the NCTCOG Ad Hoc Committee on Wastewater Reuse are acknowledged. Of particularly great value have been data and comments received from Mr. H. R. Drew of the Texas Electric Service Company, Mr. F. C. Justice of the Dallas Power & Light Company and Mr. Robert Caudel of the Texas Power & Light Company.

REFERENCES

1. Clarke, Frank E., "Industrial Reuse," Ind. and Engrg. Chem. 54:2, 18, Feb.1962.

2. Connell, C. H., "Utilization of Wastewater," Industrial Wastes, Nov. - Dec. 1957.

3. Cummings, R.O., "The Use of Municipal Sewage Effluent in Cooling Towers," Meeting No. 41, Cooling Tower Institute, June 1964, New York, New York.

4. Dallas Power & Light Company, 1968 Annual Report.

5. Drew, H.R., and Tilton, J. E., "Thermal Requirements to Protect Aquatic Life in Texas Reservoirs," Journal WPCF,April, 1970.

6. Fleming, R. G. and Jobes, H. D., "Water Reuse: A Texas Necessity." Journal WPCF, Sept., 1969.

7. Fleming, R. R., "Water Reuse By Design," American City, Oct., 1963

8. Harvey, L. and Cantrell, R. "Use of Sewage Effluent for Production of Agricultural Crops," Report 9, prepared by the Texas Technological College for the Texas Water Development Board, Dec., 1965.

9. Humphrey, F. C., "Sewage Effluent in Use as Power Plant Circulating Water," Proc., 14th Purdue Industrial Waste Conf., 1959.

10. Johnson, W. H. "Treatment of Sewage Plant Effluent for Industrial Reuse," Eimco document, reprinted from Proc., Engrs. Soc. of Western Penna., undated.

11. Knoles, L. H., Nevada Power Co., personal letter to Public Service Dept., City of Burbank, California.

12. McMichael, F. C. and McKee J. E., "Research on Wastewater Reclamation at Whitter Narrows," Calif. State Water Quality Control Board, Sacramento, California, 1965.

13. Merrell, J. C., Jr., et al., "Santee Recreation Project, Santee, California, Final Report," report WP-20-7, 1967.

14. Metzler, D. F., et al., "Emergency Use of Reclaimed Water for Potable Supply at Chanute, Kan.," Journal AWWA, Vol. 50, No. 8 Aug., 1958.

15. Metzler, D. F., and Russelmann, H. B., "Wastewater Reclamation as a Water Resource," Journal AWWA, Vol 60, Jan., 1968.

16. Nichols, M.C., "Industrial Use of Reclaimed Sewage Water at Amarillo," J. AWWA, 47, 1955.

17. Robinson, E. W., "Reclaimed Water Cools Station Condenser," Electrical World, p. 36,30 Jan. 1961.

18. Salzman, M. G. and Elliott, Louis, "Type of Water Supply Influences Location and Layout of Texas Steam-Electric Plant," Civil Engineering, May, 1951.

19. Scherer, C. H., "Sewage Effluent is Cheaper than City Water," Wastes Engineering, March, 1959.

20. Scherer, C. H., "Industrial Reuse of Sewage Plant Effluent," Chapter 23 of Texas Manual for Sewage Plant Operators, 1964.

21. Scherer, C. H., and Alexander, D. E. "Wastewater Transformation at Amarillo," Journal Sewage and Ind. Wastes, 1959.

22. Stevens, D. B., "Wastewater Reuse," Journal WPCF, Vol. 40 April, 1968.

23. Sullivan, T. F., "Sewage Effluent Used for Industrial Water," Journal San. Engineering Div., ASCE paper 1679, Sa-3, June, 1958.

24. Terry, S. L., "Economic Utilization of Wastewater Plant Effluent for Power Plant Cooling Water," Manuscript, Southwestern Public Service Co., Amarillo Texas, undated.

25. Texas Electric Service Company, Annual Report 1968.

26. Texas Power & Light Company, 1968 Annual Report.

27. Texas Utilities Company, Annual Report 1968.

28. Texas Water Development Board, "The Texas Water Plan," November, 1968.

29. Veatch, N.T., "Industrial Uses of Reclaimed Sewage Effluents, " Sewage Works Journal, 20,3, 1948.

30. Wells, D. M. and Gloyna, E. F., "Estimating the Effects of Return Flows," J. AWWA, Vol. 5, No. 7, July 1967.

31. Whetstone, George A., "Reuse of Effluent in the Future, with an Annotated Bibliography," Report 8, prepared by the Texas Technological College for the Texas Water Development Board, Dec. 1965.

32. Wolman, Abel, "Industrial Water Supply from Processed Sewage Treatment Plant Effluent at Baltimore, Md.," Sewage Works Journal 20, 15, 1948.

33. Woodburn, J.D., Public Service Department, Burbank, Calif., personal communication to J.E. McKee (CDM).

ADVANCED WASTEWATER TREATMENT PROCESSES

During the past 10 years a variety of processes have been investigated for possible use in obtaining higher degrees of treatment than are provided by the conventional "secondary" treatment processes. These can be classified by the type of contaminant to be removed as follows:

1. Suspended solids removal
2. Organics removal
3. Nutrient removal
4. Inorganic chemical removal.

A number of processes for the removal of these contaminants are being investigated at the Dallas Water Reclamation Research Center. This center is described in Chapter IV.

SUSPENDED SOLIDS REMOVAL

The processes for high suspended solids removal utilize equipment similar to or the same as those which have been used for some time in water treatment. Such equipment included microstrainers, diatomaceous earth filters and rapid sand filters either with or without a preliminary chemical coagulation step.

Either microstrainers or rapid sand filters can usually produce an effluent with a suspended solids concentration of about 5 mg/1, from a good activated sludge or trickling filter effluent without a separate coagulation step, at a cost of from 2 to 3¢ per 1,000 gal. A separate coagulation step, which would normally be done primarily for phosphate removal, would increase the cost but would make it possible for the rapid sand filters to produce a higher quality effluent. Diatomaceous earth filters do not appear to be economically competitive with the other processes.

ORGANIC REMOVAL

The processes that have received most attention for the removal of organic compounds from secondary effluents are adsorption, oxidation and foam separation. The interest in foam separation has largely died with the switch to biodegradable surface active agents in household detergents in 1965. A variety of oxidizing agents have been investigated on a laboratory scale but none have appeared economically attractive for general use as yet. Further investigation is continuing, however.

Adsorption on activated carbon appears to be the most generally useful process for removing the organic chemicals remaining in secondary effluents. Most attention has been given to the use of granular carbon in packed beds or filters, but fluidized beds of granular carbon have been studied as has powdered carbon in single or multiple stages. Activated carbon filters are being investigated at Dallas. Carbon regeneration is necessary to achieve good economy.

A 2.5 mgd plant at Lake Tahoe California was operated from 1965 to 1967 at a cost for carbon treatment of approximately 4¢ per 1,000 gal. The carbon bed treatment was preceded by coagulation and sand filtration. At Pomona, California where activated

sludge effluent was applied directly to activated carbon, the projected cost for a 1
mgd plant based on results from a 200 gpm pilot plant was about 8¢ per 1,000 gal. A
Pomona the Chemical Oxygen Demand (COD) was reduced from 47 to 10 mg/l in th
carbon beds. In general, the total removal of BOD in a plant utilizing such a proce
following the activated sludge process may be expected to approximate 98 percent.

NUTRIENT REMOVAL

Concern over eutrophication has prompted a considerable amount of development o processes for removing phosphate and nitrogen from wastewaters. Eutrophication i discussed in Chapter III.

Phosphate removal has received the greatest attention and several plants are no operational in the United States. Most of the processes are based on precipitation o phosphate with either lime, an aluminum salt or an iron salt. The Dallas facility wi investigate the use of all of these chemicals. The chemicals may be added to primar tanks, to activated sludge aeration tanks or in separate facilities followin conventional secondary treatment. In the treatment plant schematic flow diagram Fig. VI-1, the chemicals are shown added to the aeration tanks. In some processes th lime is at least partially recovered by recalcining of the sludge. Efforts at recoverin aluminum salts have not been successful to date. Chemical costs are a major part of th process cost. Removal efficiency depends largely on the amount of chemical fed and i commonly of the order of 90 percent. Typical costs run from about 5 to 9¢ per 1,00 gal.

Nitrogen removal has generally been by biological denitrification or by stripping o ammonia. Nitrogen concentrations of 1 to 2 mg/l in the effluent may be obtained b these processes. In the former process the soluble nitrogen in the waste is converted t nitrate usually in an activated sludge system. Nitrification may also be accomplishe on trickling filters. Biological wastewater treatment process designed conventionall for carbonaceous and solids removal, however, are inefficient and unreliable for th removal of nitrogen and phosphate.

A two-stage activated sludge plant has recently been designed for the Metropolita Sanitary District of Greater Chicago which provides aeration stages for th development of two separate sludges. In the first stage the bulk of the carbonaceou material is removed, and in the second aeration stage the growth of sludge would b comparatively slow being controlled largely by the growth rate of the nitrifyin organisms. Thus, optimum conditions can be developed for maximum nitrification i the second state. The nitrate is reduced to nitrogen gas by providing an anaerobi environment in which a bacterial flora develops which utilizes nitrate instead o dissolved oxygen as a hydrogen acceptor. The nitrogen gas then goes off to th atmosphere.

Three systems have been investigated for denitrification; activated carbon column activated sludge and packed rock beds. At Pomona, California it was observed th some denitrification was occurring in the activated carbon columns being used f removal of organic chemicals. It was found that by feeding a carbon source to th influent to the columns approximately 90 percent reduction of nitrate could b obtained. It was later found that other media served the purpose as well as activat carbon. A residence time of the order of five minutes in the packed bed was found be adequate. Methanol was selected as the chemical to be used as the carbon source.

AD-A036 540 CAMP DRESSER AND MCKEE BOSTON MASS F/G 13/2
UPPER TRINITY RIVER BASIN COMPREHENSIVE SEWERAGE PLAN. VOLUME I--ETC(U)
JUL 70

UNCLASSIFIED NL

4 OF 5
AD
A036540

An activated sludge process has been used in which the flora is developed in a stirred but not aerated tank. The sludge is then separated from the liquid in a sedimentation tank. A residence time in the stirred reactor of about two hours is used. Methanol is the preferred carbon source.

An upward flow anaerobic coarse rock bed, similar to a trickling filter, with a residence time of about 45 minutes, has also been used for denitrification. Chemical costs of about 2 to 3¢ per 1,000 gal have been reported. Capital costs for denitrification may be negligible if packed rock beds are also used for removal of organic chemicals or suspended solids. In the other processes capital costs add about 3 to 4¢ to the cost per 1,000 gal of waste treated.

At high pH ammonia in wastewater is largely in the un-ionized form and can be stripped from the water by air. This is usually done by trickling the water downward through a packed tower through which air is blown upward by large fans. The process can be combined conveniently with the use of lime for phosphate removal to raise the pH to a level suitable for ammonia stripping. A drawback to the process in many climates is the fact that the efficiency of ammonia stripping drops markedly as temperatures decline. At Lake Tahoe the estimated cost for ammonia stripping was 1.4¢ per 1,000 gal for a 7.5 mgd plant, exclusive of chemical cost.

The Dallas Water Reclamation Research Center is sufficiently flexible to permit investigations of a number of process combinations to achieve nutrient removal. Among these processes are trickling filters, activated sludge, activated carbon filters, multi-media filters and chemical treatment.

Nutrient removal at the present time appears to be most practicable for larger plants where sophisticated equipment and highly skilled operation may be provided. For isolated smaller plants the removal of phosphate and nitrogen from wastewater with processes requiring close control may not be warranted, and the use of tertiary stabilization ponds may be justified. Within the study area joint and other large treatment plants are expected to treat the wastewater from approximately 85 percent of the total population by 1990. Thus the additional nutrient removal which can be obtained by smaller plants serving the remaining 15 percent of the population is small.

INORGANIC CHEMICAL REMOVAL

None of the conventional waste treatment processes nor any of the more advanced processes previously mentioned remove any substantial part of the dissolved inorganic salts in wastewater. Most of the processes that have been studied for saline water conversion have also been investigated for wastewater treatment. These include distillation, electrodialysis, freezing, ion exchange and reverse osmosis. No full scale plants have as yet been constructed as part of wastewater renovation. The cost of such treatment is generally high and would be justified only if the wastewater were to be directly reused. All of these plants produce a wastewater effluent containing the dissolved salts removed in the process, and in most places the disposal of this waste would be difficult and costly.

OTHER PROCESSES

Physicochemical Treatment. In order to achieve extremely high BOD removals and the removal of nutrients from wastewater in a more economical and compact manner

sludge effluent was applied directly to activated carbon, the projected cost for a 10 mgd plant based on results from a 200 gpm pilot plant was about 8¢ per 1,000 gal. At Pomona the Chemical Oxygen Demand (COD) was reduced from 47 to 10 mg/l in the carbon beds. In general, the total removal of BOD in a plant utilizing such a process following the activated sludge process may be expected to approximate 98 percent.

NUTRIENT REMOVAL

Concern over eutrophication has prompted a considerable amount of development of processes for removing phosphate and nitrogen from wastewaters. Eutrophication is discussed in Chapter III.

Phosphate removal has received the greatest attention and several plants are now operational in the United States. Most of the processes are based on precipitation of phosphate with either lime, an aluminum salt or an iron salt. The Dallas facility will investigate the use of all of these chemicals. The chemicals may be added to primary tanks, to activated sludge aeration tanks or in separate facilities following conventional secondary treatment. In the treatment plant schematic flow diagram, Fig. VI-1, the chemicals are shown added to the aeration tanks. In some processes the lime is at least partially recovered by recalcining of the sludge. Efforts at recovering aluminum salts have not been successful to date. Chemical costs are a major part of the process cost. Removal efficiency depends largely on the amount of chemical fed and is commonly of the order of 90 percent. Typical costs run from about 5 to 9¢ per 1,000 gal.

Nitrogen removal has generally been by biological denitrification or by stripping of ammonia. Nitrogen concentrations of 1 to 2 mg/l in the effluent may be obtained by these processes. In the former process the soluble nitrogen in the waste is converted to nitrate usually in an activated sludge system. Nitrification may also be accomplished on trickling filters. Biological wastewater treatment process designed conventionally for carbonaceous and solids removal, however, are inefficient and unreliable for the removal of nitrogen and phosphate.

A two-stage activated sludge plant has recently been designed for the Metropolitan Sanitary District of Greater Chicago which provides aeration stages for the development of two separate sludges. In the first stage the bulk of the carbonaceous material is removed, and in the second aeration stage the growth of sludge would be comparatively slow being controlled largely by the growth rate of the nitrifying organisms. Thus, optimum conditions can be developed for maximum nitrification in the second state. The nitrate is reduced to nitrogen gas by providing an anaerobic environment in which a bacterial flora develops which utilizes nitrate instead of dissolved oxygen as a hydrogen acceptor. The nitrogen gas then goes off to the atmosphere.

Three systems have been investigated for denitrification; activated carbon columns, activated sludge and packed rock beds. At Pomona, California it was observed that some denitrification was occurring in the activated carbon columns being used for removal of organic chemicals. It was found that by feeding a carbon source to the influent to the columns approximately 90 percent reduction of nitrate could be obtained. It was later found that other media served the purpose as well as activated carbon. A residence time of the order of five minutes in the packed bed was found to be adequate. Methanol was selected as the chemical to be used as the carbon source.

than conventional processes, an FWQA research contract has recently been carried out on physicochemical treatment on a pilot-plant scale. This treatment process involves preliminary treatment, coagulation and clarification, carbon adsorption and dual media filtration. This process eliminates the use of conventional secondary treatment processes and has advantages in terms of space requirements and the fact that treatment is not upset by large fluctuations of influent sewage quality.

BOD removals reported from the pilot plant averaged about 97 percent despite variations in waste strength and composition. The effluent was essentially free of suspended solids and contained only about 5 mg/l or less of BOD . In addition, the physicochemical treatment process is reported to achieve about 90 percent removal of phosphate and about 95 percent of nitrate.

The cost of the physicochemical treatment process to produce an effluent quality sufficient to meet most demands for reuse and pollution control was estimated to be about 16¢ per 1,000 gal including amortization of capital. This compares with a reported cost of 11¢ per 1,000 gal for conventional primary-secondary biological treatment and with 26¢ per 1,000 gal for comparable tertiarty treatment added to a conventional secondary treatment plant. This process has not as yet been demonstrated on a full-scale plant but results obtained from the pilot plant studies to date appear promising.

Induced River Aeration. As discussed under surface runoff in Chapter III, research is now beginning to show that, even in well-regulated areas, the recorded effluents (i.e from municipal plants and industries) may constitute perhaps only one-third of the total pollution load entering a river system,. In such a situation expensive advanced waste treatment plants may be insufficient to achieve the desired water quality.

Induced river aeration by means of mechanical surface aerators or diffused air aerators located in a river has been studied by a number of investigators. Whipple and Coughlan have reported that the annual cost to achieve a D.O. level of 4 mg/l on the Passaic River by instream aeration would be about one-quarter the cost of advanced waste treatment for this purpose. A systems analysis of the Potomac River estuary by Davis showed that, after 90 percent removal of BOD has been achieved, instream aeration was a much more economical means of obtaining further removal than any practicable alternative.

Instream aeration would appear to offer a means of maintaining D.O. levels in the Trinity River when canalization is complete and channel sections are controlled. However, such aeration will not remove phosphate and nitrogen. As discussed in Chapter IV such nutrients constitute a prime threat to maintenance of satisfactory water quality in the streams and reservoirs of the Trintiy River Basin.

CONCLUSIONS

Advanced wastewater treatment processes for the removal of suspended solids, organics and nutrients may be most successfully and economically employed in large centralized (joint) treatment plants. Such processes generally are not considered feasible at present for isolated smaller plants because of cost and operational factors greatly exceeding the possible benefits. Instream aeration does not appear to hold

much promise in the Trinity River because neither phosphates nor nitrogen are removed to any significant degree by this process. However, the physicochemical treatment process holds promise for the North Central Texas area and should be considered as a possible alternative to the standard sequence of primary, secondary and tertiary processes.

REFERENCES

1. Barth, E.F., Brenner, R.C. and Lewis, R.F., "Combined Chemical-Biological Approach to Control Nitrogen and Phosphorus in Wastewater Effluents," Journal WPCF, Vol. 40, 1968.

2. Davis, R.K., "The Range of Choice in Water Management," Johns Hopkins Press, 1968.

3. Eberhardt, W.A. and Nesbitt, J.B., "Chemical Precipitation of Phosphorus in a High-Rate Activated Sludge System," Journal WPCF, Vol. 40, 1968.

4. Eliassen, R. and Tchobanoglous, G., "Chemical Processing of Wastewater for Nutrient Removal," Journal WPCF, Vol. 40, May, 1968, Part 2.

5. Horn, J.A., DePrater, B.L., and Witherow, J.L., "Phosphate Removal at Fort Worth, Texas," Water and Wastes Engineering, July, 1969.

6. Lynam, B.T., Ettelt, G., and McAloon, T., "Tertiary Treatment at Metro Chicago by Means of Rapid Sand Filtration and Microstrainers," Journal WPCF, Vol. 41, Feb., 1969, Part I.

7. Parkhurst, J.D., Dryden, F.D., McDermott, G.N., and English, J., "Pomona Activated Carbon Pilot Plant," Journal WPCF, Oct., 1967, Part 2.

8. Schmid, L.A. and McKinney, R.E., "Phosphate Removal by a Lime-Biological Treatment Scheme," Journal WPCF, Vol. 41, July, 1969.

9. Selechta, A.F., and Culp, G.L., "Water Reclamation Studies at the South Tahoe Public Utility District," Journal WPCF, Vol. 39, May, 1967.

10. Smith, R., "Cost of Conventional and Advanced Treatment of Wastewater," Journal WPCF, Sept., 1968.

11. Sosewitz, B. and Bacon, V.W., "Chicago's First Tertiary Treatment Plant," Water and Wastes Engineering, Sept., 1968.

12. Sosewitz, B. and Bacon, V. W., "Tertiary Wastewater Treatment-On its Way," Civil Engineering, ASCE, Nov., 1969.

13. Spiegel, M. and Forrest, T.H., "Phosphate Removal: Summary of Papers," Journal S.E.D., ASCE, Oct., 1969.

14. Tchobanoglous, G., "Filtration Techniques in Tertiary Treatment," Journal WPCF, Vol. 42, April, 1970.

2?

15. Tossey, D. , Fleming, P. J., and Scott, R. F., "Tertiary Treatment by Flocculation and Filtration", Journal Sanitary Engineering Div., ASCE, Feb., 1970.

16. Vacker, D., Connell, C. H., and Wells, W. N., "Phosphate Removal Through Municipal Wastewater Treatment at San Antonio, Texas," Journal WPCF, Vol. 39, May, 1967.

17. Weber, J., Hopkins, C. B., Bloom, R. Jr., "Physicochemical Treatment of Wastewater," Journal WPCF, Vol. 42, Jan., 1970.

18. Whipple, W., Jr., et al, "Instream Aeration of Polluted Rivers," Water Resources Research Institute, Rutgers University, New Brunswick, N. J., 1969.

19. Whipple, W., Jr. and Coughlan, F. P., Jr., "Instream Aerators for Polluted Rivers," ASCE National Water Resources Engineering Meeting, Memphis, Tenn., Jan., 1970.

TREATMENT AND DISPOSAL OF SEWAGE SLUDGE

GENERAL DISCUSSION

Sludge treatment and disposal is a very important function of wastewater treatment facilities. The efficient treatment and disposal of sewage sludge is essential to the attainment of water quality objectives in the North Central Texas region.

Sludge is produced in wastewater treatment plants as a result of the liquid-solids separation processes employed and is generally collected in sedimentation tanks as shown on Fig. VI-1. Such sludge may be defined as a semi-liquid waste having a total solids concentrations of at least 2,500 mg/l, and which can flow by gravity and be pumped. The handling and disposal of grit and screenings is frequently included with the sludge.

Treatment plant designs must consider sludge handling and disposal as integral parts of the total waste treatment process.

It is commonly recognized that sludge treatment and disposal is the most difficult and expensive part of wastewater treatment. Often it represents 25 to 50 percent of the total capital and operating cost of a wastewater treatment plant despite the fact that the volume of sludge produced is frequently less than one percent of the total volume of wastewater treated. Costs for the various processes discussed hereinafter generally are given in terms of dollars per ton of dry solids in the process feed. Each ton of dry solids applied to sludge treatment and disposal processes may be considered roughly equivalent to the load imposed by 15,000 to 20,000 people in one day.

The problem is aggravated by ever-increasing volumes of sludge from domestic and industrial sources coupled with reduced availability of land for economical disposal and lessening public tolerance of air and water pollution. McCarty has estimated that the volume of waste sludge will increase 60 to 70 percent nationwide within the next 15 years. Comparable increase can be expected in the study area and requires thorough evaluation to determine the most economical method of sludge treatment and disposal at each location. Such an evaluation should include particularly the consideration of methods which permit the liquid, solid and nutrient portions of sludge to be returned to the natural environment wherever this can be usefully and safely accomplished.

The objectives of sludge treatment and disposal are:

1. To decompose, biologically or chemically, organic matter in the sludge to a relatively stable inoffensive material.

2. To reduce the sludge volume to facilitate processing and ultimate disposal.

3. To destroy or control pathogens.

4. To prevent air and water pollution.

5. To utilize by-products of the process if possible to minimize the overall cost of operation.

Burd listed in his 1968 report to the FWPCA the following as the basic factors to be considered in the selection of the sludge treatment and disposal processes for accomplishing the above objectives:

1. Character of the sludge; raw, digested, or industrial
2. Land availability
3. Suitability of sludge disposal by dilution
4. Local possibilities for using sludge as a soil conditioner or fertilizer
5. Climate
6. Capital and operating costs
7. Size and type of wastewater treatment plant
8. Proximity of the plant to residential area and local air pollution control regulations

Improvements in sludge treatment and disposal technology are needed to achieve the above objectives on the broad scale required by future population growth. Toward this end existing and new processes are being investigated by organizations all over the world to obtain greater efficiency and economy in sludge disposal.

CURRENT PRACTICE

The sludge treatment and disposal processes currently utilized by the major sewage treatment plants in the study area are summarized in Table XI-3. It may be seen that the most commonly practiced methods of sludge treatment and disposal are digestion (anaerobic) followed by lagoons and/or drying beds. Such methods, when properly carried out, may be, for long periods of time, satisfactory from the standpoints of water quality, health and odor.

Hinesly and Sosewitz state that, "While sludge digestion followed by lagooning is a traditional method of solids disposal in many communities, large urban areas, and on an increasing scale even smaller communities are faced with serious land use problems, aesthetic considerations, and costs when reaching a decision on a solids disposal program." Indeed, the City of Fort Worth has recently decided to abandon the Riverside Sewage Treatment Plant for similar land use and aesthetic reasons.

In 1969 Black & Veatch, Consulting Engineers recommended a long-range sludge disposal plan for the Dallas White-Rock Plant. This plan included recommendations for pumping digested sludge to the Dallas South Side plant site, lagooning the sludge in two new lagoons, dredging of solids at about five year intervals and disposal on land. Also proposed in the report were a test program to study application methods and rates of sludge disposal by irrigation and an odor control program.

The City of Fort Worth is currently constructing about 120 acres of sludge lagoons. It is hoped that dried sludge from the lagoons may be utilized as fertilizer.

TABLE XI-3. SLUDGE TREATMENT AND DISPOSAL METHODS AT EXISTING MAJOR PLANTS

Sewage Treatment Plant						
Node	Name	Type of Plant	Sludge Treatment Process	Estimated Sludge Production lb/day(1)	Sludge Disposal Process	Remarks
1D-161	TRA Ten Mile Creek	Primary Activated Sludge	Thickening Digestion Centrifugation	20,000	Land Application of Dewatered Sludge	Under construction
1F-146	Dallas-South Side	Oxidation Ponds	Oxidation Ponds	51,000	Oxidation Ponds	Possible future sludge lagoons, dredging and application
1I-175	Dallas-White Rock	Primary Trickling Filter	Digestion	167,000	Anaerobic and Aerobic lagoons	-
3D-23	Garland-Duck Creek	Primary Trickling Filters	Digestion	104,000	Drying Beds Land Application	
4A-166	Trinity River Authority	Primary Trickling Filters Stabilization Ponds	Thickening Digestion	135,000	Drying Beds Land Application	Formerly sold liquid digested sludge for land application
5G-180	Fort Worth - Village Creek	Primary Activated Sludge	Thickening Digestion	192,000	Lagoons Drying	Possible sale of dried sludge
5M-101	Fort Worth - Riverside	Primary Trickling Filter	Digestion	-	Lagoons Drying Beds	Plant to be phased out
			TOTAL	669,000		

Note: (1) Based on average 1990 Suspended Solids loads, dry solids after digestion

From information obtained on several of the larger treatment plants in the study area sludge disposal processes practiced often do not constitute ultimate sludge disposal (the beneficial contact between sludge and natural environment). It is reported that in some cases sludge disposal is practiced during high river levels by the direct discharge of sludge from lagoons to the river. In other cases river levels reportedly overtop lagoon levees and carry away considerable quantities of sludge. Such practices defeat the purposes of sewage treatment, i.e. to abate water pollution. It is apparent that the need for instituting acceptable ultimate sludge disposal practices in the North Central Texas region is essential.

SLUDGE TREATMENT PROCESSES

Sludge treatment processes are combinations of those methods by which sewage (or industrial waste) sludge may be thickened, digested, conditioned, dewatered (by vacuum filtration, centrifugation or on drying beds) or burned. The effectiveness of the waste treatment process and, therefore, the quality of the receiving water is greatly influenced by the efficiency of these sludge handling methods. Unless these are of the highest efficiency, filtrates, centrates, elutriates and particularly digester supernatant liquors containing fine solids, will overload clarification and biological treatment units; thus lowering the overall treatment efficiency.

Air pollution may be caused by any number of sludge treatment processes including incineration, heat drying, lagooning, sand bed dewatering, and raw sludge thickening. In this case, the waste treatment objective of maintaining good public relations is in jeopardy, and the quality of the air in the vicinity of the plant is degraded.

Sludge thickening reduces the amount of moisture in the sludge and, therefore, its volume. This reduced volume permits saving in subsequent processing and disposal costs which may be appreciable in larger plants. For very small wastewater treatment plants, however, the saving achieved may not justify the extra cost for the thickening facilities. Any evaluation of thickening should consider the economy *resulting from* the production of thicker sludge.

Three types of thickening processes are commonly used in sewage sludge treatment, gravity thickening, flotation thickening and centrifugation. Additional methods involve the biological flotation of organic sludges but are not commonly used.

Gravity thickening is essentially *a sedimentation process combined with slow stirring* to promote agglomeration and to aid in the destruction of bridge networks which trap water within the sludge. Gravity thickening can reduce sludge volumes by one-half with consequent reduction in costs of digestion, dewatering, etc. Beaumont, Texas in 1956 reported saving $175,000 in plant construction costs by using thickeners which allowed digester capacity to be reduced from 510,000 cu ft to 240,000 cu ft.

Optimum thickening results have been achieved when feed solids concentration is between 0.5 and 1.0 percent. At Beaumont normal operations produced a thickened primary and trickling filter sludge having 8.7 percent solids. The thickening of activated sludge with the use of lime has increased solids concentrations from 0.6 to 3.5 percent.

The disadvantages of gravity thickeners are the high initial cost (which may be offset by saving other process costs) and the need for constant attention to maintain optimum operating conditions. Poor thickening may upset the operation of the entire treatment plant due to the recycling of thickener overflow containing high suspended solids and BOD.

Flotation thickening uses fine rising gas bubbles to bring solid particles to the surface where it is skimmed off. The gas is usually introduced by injecting air into the feed sludge under pressure. Flotation thickeners are particularly suitable for activated sludge. A much higher loading rate is used than for gravity thickeners and the solids concentration of the end product is about twice as high as that from gravity thickeners. The disadvantages of flotation units include their sensitivity to a large number of factors which results in irregular performance and high operating and maintenance costs, and the need for polymer addition to achieve acceptable performance.

Sludge thickening by centrifugation is a very promising process especially where adequate space is not available for other types of thickeners. Solid bowl centrifuges frequently are not economical for thickening waste activated sludge. Both disc centrifuges and solid-bowl centrifuges can be used for sludge thickening. The latter are usually operated at lower speeds and are more commonly used in wastewater treatment plants due to their better operating characteristics. In a solid-bowl centrifuge, the solid-liquid separation is accomplished in a cylinder with a truncated cone end section rotating at speeds of about 3,000 revolutions per minute. Centrifuges produce end products with higher solids concentrations than those from gravity or flotation thickeners. In fact, a solid-bowl centrifuge can combine thickening and dewatering in one step and produce a sludge suitable for incineration or land filling without additional treatment. The disadvantages of centrifugation include high operating cost and a relatively poor solids capture efficiency if chemicals are not used.

Gravity thickening generally provides the least expensive method if adequate space is available. Flotation thickening is less expensive than gravity thickening in capital cost but more expensive in operating cost. Centrifuges are relatively low in capital costs but have high operating costs. Centrifuges may, however, not only thicken but dewater sludge in the same step. Table XI-4 presents the general ranges of total capital and operating costs under average conditions for the three types of thickening, both with and without chemicals. These costs must be considered with the costs of the entire treatment and disposal process before a choice is made. The costs of thickening are greatly increased by the use of chemicals, and higher costs are generally associated with the thickening of biological sludges.

Sludge digestion involves the biological decomposition of organic matter in sewage sludge. Well digested sludge is stable, higher in solids concentration than raw sludge, easier to dewater for ultimate disposal and relatively low in risk as a potential public health hazard due to the destruction or reduction of pathogenic organisms. The odor of digested sludge is also much less offensive than the odor associated with raw undigested sludge. Two types of digestion are used in wastewater treatment systems; anaerobic or aerobic digestion. Anaerobic digestion is practiced at six of the seven plants listed in Table XI-3.

TABLE XI-4. COMPARISON OF SLUDGE THICKENING COSTS

Type of Thickener	Range of Unit Costs (Dollars/Ton Dry Solids in Feed)	
	Without Chemicals	With Chemicals
Gravity	1.5 - 5	----
Flotation (Air)	6 - 9	11 - 15
Centrifuge	4 - 10	7 - 20

TABLE XI-5. COMPARISON OF SLUDGE DEWATERING COSTS

Dewatering Process	Range of Unit Costs (Dollars per Ton Dry Solids in Feed)
Drying on Sand Beds	3 to 20
Vacuum Filtration	8 to 50
Centrifugation (no chemical addition)	5 to 35
Centrifugation (with polymer addition)	11 to 55

Anaerobic sludge digestion as normally practiced, takes place at a temperature of around 95°F for about 30 days in conventional single-stage digesters. About 50 to 60 per cent of the volatile solids content of the sludge is destroyed. The supernatant from unmixed digestion tanks is decanted and usually returned to the influent end of the treatment plant where it often interferes with effective sedimentation. Efficient digestion demands separate tanks for thorough mixing and proper solid-liquid separation, and this has resulted in the development of two-stage high-rate systems. About two-thirds of the decomposition occurs in the heated and mixed primary digester in about 10 days. The secondary digester is usually not heated and often has no mixing device in order to promote better sludge thickening and compaction. Anaerobic digesters are very expensive in capital cost and present many operational problems. To reduce digester sizes and costs they are frequently preceded by sludge thickening facilities.

In 1965 Chicago reported a total cost of $22 per ton of feed sludge to handle activated sludge (3.5 percent solids) by digestion and lagooning. The costs range from about $32 per ton for 2 percent sludge to almost $14 per ton for 8 per cent sludge. Gas production resulting from the decompostion of organic material in the sludge may be utilized to generate power and for heating to help offset high costs of the digestion process. Studies are being made to operate anaerobic digesters in the thermophilic range (about 120° F) to improve process efficiencies.

Aerobic sludge digestion is a relatively new process which is receiving increasing attention. An aerobic digester is often an open tank with a suitable air supply system. Aerobic digesters having a detention period of about 10 days produce end products which are odorless, stable and easy to dewater. In comparison with anaerobic digestion more nutrients are conserved, and this is desirable if the sludge is to be used as fertilizer. The reduction in volatile solids is about the same as for anaerobic digestion. The initial cost is low. The main disadvantage of aerobic digestion is the higher power requirement for mixing and air supply as compared with anaerobic digestion.

Aerobically digested sludge usually has better dewatering characteristics than anaerobic sludge. Anaerobic digestion is less expensive than aerobic digestion, particularly at larger plants where power cost is a major factor. Aerobic digestion may be advantageous at smaller treatment plants and industrial waste treatment installations. High rate anaerobic digestion generally is more economical than conventional (low rate) anaerobic digestion because of the shorter detention time, smaller size tanks required and decreased operational problems. The reported range of capital and operating costs for anaerobic digestion alone is $5 to $18 dollars per ton of dry solids. Reliable cost data on aerobic digestion are not available.

The question of whether sludge digestion is applicable in a given situation depends primarily upon the methods selected for ultimate disposal of the sludge. Sludge digestion is preferable to other methods of sludge treatment when the sludge can be utilized for land reclamation, crop land application or landfill. It is also preferable where sludge is to be dried on sand beds, particularly those which are not covered and are in close proximity to residential areas where odor problems may arise from undigested sludge.

Sludge Conditioning. Sludge conditioning involves the treatment of the sludge to facilitate subsequent thickening or dewatering of the sludge. It may be accomplished by either chemical or physical means, but chemical sludge conditioning is the most commonly practiced.

In chemical sludge conditioning, chemical conditioners act as coagulants which agglomerate solids and cause a release of water from the solids. Ferric chloride, lime and polyelectrolytes are commonly used. A substantial savings in chemical costs can be achieved in anaerobic sludge digestion by means of elutriation. Elutriation is a process in which the digested sludge is mixed first with water of lower alkalinity and then is separated by means of sedimentation. Elutriation also improves the thickening property of the digested sludge by flushing away the entrained gas bubbles and fine particles. The chief disadvantage of elutriation is its poor solids capture efficiency which is sometimes below 70 per cent. The overflow liquid from the elutriation tanks may create stream pollution problems if it is not properly treated. Furthermore the overflow liquid may upset the treatment plant operation because of the high solids content, particularly if it is discharged to the head of the plant. Elutriation usually eliminates the need for lime and reduces the need for ferric chloride by 50 to 80 per cent. Savings in chemical costs normally exceed $2.00 per ton. Elutriation of digested activated sludge at the Los Angeles Hyperion Sewage Treatment Plant was reported to have reduced chemical costs from $20.00 to about $4.00 per ton of dry solids.

Physical sludge conditioning may be accomplished by either freezing or heating of the sludge. It is believed that these methods of physical sludge conditioning involve the destruction of the cell structure of microorganisms within the sludge. Complete freezing of the sludge has been found to improve its dewatering characteristics appreciably. However, this process is very expensive. Sludge conditioning by heating is a process usually applied to raw sewage and involves cooking the sludge for one-half to three-quarters of an hour at pressures of 150 to 250 psi (pounds per square inch) and a temperature of 300°F to 400°F. The heat treated sludge is completely sterilized under these conditions and easy to dewater. Heat treatment of the sludge in this manner renders the sludge innocuous and may permit its use for land reclamation. Reliable cost of heat treatment sludge conditioning is not available but the costs for freezing 5 percent sludge range from about $32.00 per ton of dry solids in small plants to $45.00 in larger plants.

Sludge conditioning processes improve the efficiency of sludge handling and disposal systems and may be necessary for the satisfactory operation of the system. It is, however, quite costly; the cost of chemical conditioners may account for 40 percent of the total operating cost of the treatment plant. Heat treatment costs appear to be competitive with those for chemical sludge conditioning. However, further investigations are needed before large scale applications of the heating process may become practical.

Sludge Dewatering. Sludge dewatering is employed to reduce the moisture content of sludge to a level which allows its further treatment by sludge drying and combustion or disposal by application to land. Sludge dewatering differs from thickening in that the sludge is processed into a non-liquid form which permits its transfer by conveyor, truck or other method. Sludge dewatering processes commonly employed in wastewater treatment include sand bed drying, vacuum filtration and centrifugation.

Sludge drying on sand beds is the simplest and most common sludge dewatering process. Uncovered sand beds are employed at numerous treatment plants in the

North Central Texas region. Sand bed drying is generally the most economical method of sludge treatment for small plants inasmuch as the sludge is simply spread on sand beds and left to dry to a solids concentration of roughly 50 percent, when the sludge may then be conveniently removed. Water in the sludge is removed by under-drainage and/or evaporation. Large plants seldom use this process because of the large land areas required and the difficulties involved in removing large quantities of dewatered (dried) sludge from the beds. However, the City of Fort Worth is currently constructing about 120 acres of sludge lagoons which rely on evaporation only to dry the sludge.

Vacuum filtration is commonly used for sludge dewatering at large plants. This method is being practiced at the present time to dewater chemically treated raw sludge at Arlington, Texas. In the past vacuum filtration has been considered economical only for treatment plants serving 25,000 persons or more; however, recent economic studies by others have indicated that vacuum filtration may now be economical even for plants serving less than 10,000 persons. A vacuum filter consists of a rotating cylindrical drum which is continuously passed through the sludge where it picks up solids to form a cake. The cake is partially dewatered by an applied vacuum within the drum of about 10 to 20-in of mercury and it is then discharged to conveyor belts or other methods of transfer. The moisture content of the discharge cake is about 70 to 80 percent which is suitable for incineration or landfill. Chemical sludge conditioning is required before vacuum filtration.

Centrifugation is a strong competitor with vacuum filtration. In centrifugation, sludge conditioning may not be necessary, there is no odor problem since the mechanism is totally enclosed, and reported capital and operating costs are less than for vacuum filtration. The moisture content of the dewatered sludge is comparable to that from vacuum filters. The major disadvantage of centrifugation, however, is the relatively poor solids capture efficiency as compared with that from vacuum filtration. To overcome this disadvantage the addition of polymers in the feed is often practiced, but this greatly increases the operating cost and may make centrifugation uneconomical. Unit cost of sludge dewatering processes including capital, operating and maintanance costs are listed in Table XI-5. The higher costs are generally associated with biological sludges.

Sludge Drying and Combustion. Sludge drying and combustion may achieve two important objectives: solids sterilization and reduction of sludge volume. By sterilization of the sludge the potential health risk from ultimate disposal methods is reduced as are potential water pollution problems. Reduction of sludge volume is very significant for municipalities as regards the handling and disposal of the sludge.

Sludge may be dried by mechanical means without incineration when it is desired to reduce sludge volumes and yet permit its use as a fertilizer and/or soil conditioner. Since evaporation of water consumes heat, the moisture content of the wet sludge must be kept as low as economically possible. This requirement often necessitates the use of mechanical dewatering equipment such as vacuum filters or centrifuges. A flash type incinerator/dryer may be used for the purpose.

Sludge combustion may be accomplished by incineration or wet oxidation. In sludge incineration the wet sludge is first dried by evaporation and then burned. There are three types of incinerators in use; the multiple hearth type furnace, the fluidized bed reactor and the atomized spray reactor. In a multiple hearth furnace the wet sludge is

dried and burned at a temperature of between 1,500 and 1,600°F. The ash is either transported hydraulically to a nearby lagoon or pneumatically or mechanically to a storage bin for ultimate disposal to landfill. This type of incineration is the most economical combustion method. However, air pollution problems resulting from improper operation of an incinerator may require fly ash and odor control in the exhaust gas. In the fluidized bed incinerator, wet sludge is dispersed, dried, mixed with oxygen and burned at a temperature of between 1,400 and 1,500°F in a sand bed fluidized by gas flow. The ash is carried out in the exhaust and is recovered by a wet scrubber using the sewage treatment plant effluent. This process is very efficient in the amount of excess air required and produces a clean exhaust; however, it is more expensive than the multiple hearth type incinerator. The atomized spray reactor is a relatively new device in which the wet sludge is ground to suitable size before being applied to the reactor through a sonic atomizer. The reaction is fast and complete at a temperature of about 2000° F and the dust is removed in a cyclone. The process is clean, with no associated air pollution problem, but the process is expensive and the atomizer is subject to plugging problems.

In wet oxidation combustion is accomplished in a liquid medium at a temperature of about 500° F and a pressure of over 1,000 psi. The wet sludge is ground and mixed with air before its introduction to the reactor and thickened sludge can be applied directly to the unit. The high solids concentration is desirable for economical operation, and the end product is sterile and easy to dewater. However, close control is needed to obtain optimum performance, and installations to date have experienced high operating and maintenance costs. In general, multiple hearth incinerators are much more economical than other methods of combustion even when the cost for deodorization and fly ash control are included. Fluidized bed incinerators are economically competitive for larger plants because of good exhaust quality. Total costs of the various sludge combustion processes vary considerably with size of the installation but frequently are in the range of $30 to $60 per ton of dry solids.

SLUDGE DISPOSAL PROCESSES

Ultimate disposal of sludge is considered accomplished only when the material has been removed entirely from the treatment plant in a manner that is sanitary, permanent and satisfactory to all parties concerned. One definition of ultimate sludge disposal is the beneficial contact between sludge and the natural environment.

As indicated above, sludge lagoons as currently employed are not considered to be a method of ultimate sludge disposal. Lagoons must be periodically dredged to preserve their continued usefulness, and the liquid sludge must then still be safely and effectively disposed of. In addition, lagoons are frequent sources of odor problems. Pollution can be carried by birds, insects, etc., directly from open sludge lagoons to water supply reservoirs and into contact with humans. For these reasons it is suggested that sludge lagoons be phased out at large plants serving metropolitan areas and a system involving sludge drying and processing be adopted. In this manner, sludge may become a more of a community asset rather than a liability.

The processes discussed above relate only to the treatment of the sludge prior to its ultimate disposal. The problem, however, is not solved until the sludge has been satisfactorily disposed of to the environment (generally ocean or land). The type of sludge treatment and the method of ultimate disposal selected for a given situation

are interdependent; and both are in turn governed by public health and pollution control considerations and overall economics. Presented here is a general evaluation of existing sludge disposal systems and their potential applications.

Sludge Conveyance. Methods of ocean or land disposal of sludge depend primarily upon the economic factors of distance, mode of conveyance and efficiency of conveyance. Conveyance, under prescribed conditions, is practical by tanker truck, rail, pipeline or barge. Any one or a combination of these conveyance methods may be feasible as part of the ultimate disposal of sludge from the North Central Texas region depending upon the final disposal location of the sludge.

It has been sugested that sludge may be pumped economically over distances from 25 to over 100 miles. Total annual costs for existing sludge pipeline systems are reported to range from about $3 to $7 per ton of dry solids. Sludge conveyance by pipeline can be simple, flexible, inexpensive and relatively trouble-free.

Barging of sludge to disposal areas away from the metropolitan Dallas-Fort Worth area may become feasible with the completion of the planned Trinity River Canalization Project. Disposal areas may be either on land or the Gulf of Mexico.

Ocean Disposal of Sludge. Ocean disposal as currently practiced by many large U.S. cities is accomplished by dilution of sludge conveyed to the point of disposal by pipeline or barge. Barged sludge may be in liquid or dewatered form. A study conducted by the Washington, D.C. Department of Sanitary Engineering indicated that barging of sludge distances of 200 miles may be economical. Estimated 1970 unit costs ranged from about $18 to $21 per ton of dry solids for 7.5 percent and 4.0 percent sludge concentrations respectively. These costs included thickening, digestion, elutriation, vacuum filtration and barging to sea.

Whether ocean disposal is accomplished by pipeline (outfall) or barging, the point of disposal must be so selected that no beach pollution or detrimental effects on this marine environment will occur.

Land Disposal of Sludge. Sludge may be disposed of to the land environment in either the liquid or non-liquid state. Sludges in the liquid state are those resulting from primary settling, activated sludge, sludge thickening and sludge digestion processes. Sludges in the non-liquid state are sludges from the above processes which have been in addition dewatered, dried and/or incinerated. Undigested or unconditioned primary or activated sludges are not considered desirable for land disposal because of the possibility of water pollution and hazard to health which might result from such disposal.

Liquid digested sludge contains slow conditioning agents and all elements essential to the growth of green plants and is therefore finding increasing favor as a method of ultimate sludge disposal. Digested sludge is being applied to farm land and other rural lands and communities throughout the country. As commonly practiced, there appears to be little danger that human disease or parasitic infections are transmitted through the consumption of crops grown on sludge-treated soil. In St. Marys, Pennsylvania, anaerobically digested liquid sludge has been hauled without charge and spread 1-in thick on pastures, meadows and crop lands every other year since 1964.The soil's physical and biological condition appears to be very good and there

were no complaints of objectionable odor. The New York City Park Department has been using high rate digested sludge as a topsoil for new parks and the City of Las Vegas, Nevada uses all of its sewage sludge for the development of parks, recreational areas and cemetery facilities. It has been found that the sludge has been a very useful soil builder at both locations.

The Metropolitan Sanitary District of Greater Chicago is currently experimenting with raising crops on land being irrigated with digested sludge. Basic crops being raised as part of this experiment are field corn and pasture grasses. The U.S. Public Health Service is cooperating in the project with the FWQA to assure that the disposal of sludge does not cause adverse effects on groundwater supplies and will also conduct investigations to determine the effects of the sludge on plant growth and quality. It is expected that as the project develops handling methods will be improved so that the sludge will be pumped to the site and applied by spray irrigation techniques. Current plans are directed toward the development by the year 2015 of a 21,500 acre tract of land that will have the capacity for using all of the digested sludge from Chicago's West Southwest, Calumet, and Northside waste treatment plants.

The use of liquid digested sludge for land reclamation provides a long-range solution to and provides a beneficial use of sludge which has a high organic food value. In addition it is claimed that there are no air pollution problems associated with this method of sludge disposal. The cost of digestion and land reclamation is reported to be about $20/ton of dry solids. With the availability of large acres of farm land within 50 to 75 miles of the Dallas-Fort Worth metropolitan area, consideration of this method of disposal would appear to be warranted.

The disposal of sludge in the non-liquid state is commonly termed landfill. Landfilling is commonly used for sand bed dried digested sludge and for mechanically dewatered raw or digested sludge. Frequently such materials is disposed of to a landfill or dump as other types of solid waste as discussed later in this chapter.

Landfilling is economical if land is located within a reasonable distance but as with other methods of sludge disposal care must be taken to prevent possible surface and groundwater pollution. A dewatered raw sludge should be covered with soil as a precaution against disease transmission and odor problems, and future land use of the area should be considered.

The use of sand bed dried sludge or dewatered digested sludge as a fertilizer or soil conditioner is a desirable and economical method if the demand exists within a reasonable distance. As noted previously the City of Fort Worth is currently constructing a large lagoon area where sludge from the Village Creek plant will be dried. It is planned to control the depth of the sludge on the beds to 10 or 12-in, and the area about 120 acres is expected to be ample to permit drying of the sludge by evaporation. It is hoped that the dried sludge may be utilized as fertilizer. At present the Fort Worth Riverside Plant sludge is given to anyone who wants it. The Texas Highway Department has used a considerable quantity of it.

At Amarillo, Texas sludge is removed from sand drying beds, ground, and loaded onto the customer's truck. It is reported that the demand for sludge as fertilizer exceeds the supply.

Health regulations usually allow the use of dried digested sludge on vegetable plots provided that the edible portion of the crops grow above ground or the crops are cooked before eating. Dewatered raw sludge must be sterilized during processing before any application for agricultural purposes in order to minimize health hazards. Ash disposal resulting from the incineration of sludge is relatively simple because of its comparatively small volume and inert character. Ash has been used for landfilling, road construction and other similar purposes. The cost is generally low and no sanitary problem is involved.

Comparison of Methods. It is evident that sludge treatment and disposal costs vary greatly. This statement is valid even though two similar treatment plants use identical sludge treatment processes and identical disposal methods. For this reason, detailed studies should be made of comparative costs for each particular disposal situation. Inasmuch as sludge disposal and handling generally represents between 25 and 50 per cent of total treatment plant capital and operating costs detailed studies are thoroughly justified.

For the North Central Texas region disposal of sludge at relatively small plants will no doubt continue to be through the use of sand drying beds with disposal of sludge either to landfill or used for growing crops or other vegetation by those desiring it. For the larger plants such as those proposed as joint plants under the recommended regional sewerage plan consideration should be given to sludge treatment and disposal systems including the following:

1. Sludge digestion, drying on sand beds, grinding, followed by landfill and/or soil conditioning.

2. Sludge digestion, piping of liquid sludge to land reclamation.

3. Conditioning of sludge followed by piping to land reclamation.

It should be noted that each of the above methods involves the use of sludge for some form of fertilizer, soil conditioning and/or land reclamation purpose.

In 1968 it was reported that approximately 13 percent of the COG area or about 667,000 acres of agricultural land were being fertilized using commercial fertilizers. It is estimated that by the year 1990 approximately 120,000 tons per year of dried digested sludge would be produced at the six recommended joint treatment plants. If all this sludge were applied to agricultural land instead of commercial fertilizers, average application could be as high as 360 lb per year per acre. Commercial fertilizer (5-20-20) applications on corn fields may range from 150 to 360 lb per year per acre as discussed in Chapter III. While specific nutrients in sludge must be considered in the light of fertilizer requirements for specific crops, nevertheless it is evident that the quantities of sludge available are comparable to the requirements.

Evidence to date suggests that the use of liquid digested sludge for land reclamation and soil improvement will not compete with commercial fertilizers. The reason for this primarily is that manufactured fertilizer is less expensive and easier to handle. The sludge can become expensive to apply if transportation distances are excessive. While the application of liquid sludge to land may have certain merit for the improvement of soils, it is nevertheless an aesthetically undesirable method because of the unpleasant nature of sludge and general reticence on the part of the public to

accept such practices in their vicinity. It, therefore, is conceivable that sludge from major plants in the North Central Texas region may be dried either on open sludge sand drying beds or by heating, ground as required and made availabe to the public either in bag or in bulk quantities.

In order to encourage the large-scale use of dried sludge in the quantities necessary, it would be necessary to set low prices for the sludge, even though charges may not cover the cost of sludge production. With this prospect commercial fertilizer companies might find it quite desirable to purchase the sludge in large quantities and process it for commercial sale. Detailed studies should be conducted to establish the proper disposition of the dried sludge and the charges to be made for it.

REFERENCES

1. Black & Veatch, Consulting Engineers, "Report on Disposal of Solids and Control of Odors at the Dallas-White Rock Wastewater Treatment Plant, Dallas, Texas," 1969.

2. Burd, R.S., "A Study of Sludge Handling and Disposal," Federal Water Pollution Control Administration, Washington, D. C., May, 1968.

3. Dalton, F.E., Stein, J.E., Lynam, B.T., "Land Reclamation-A Complete Solution of the Sludge and Solids Disposal Problems," Journal WPCF.

4. Dick, R.I. ed., "Sludge Treatment, Disposal and Utilization," Journal WPCF, p. 934, June, 1969.

5. Evans, James O., "Ultimate Sludge Disposal and Soil Improvement," Water and Wastes Engineering, June, 1969.

6. Hinesly, Thomas D. and Sosewitz, Ben, "Digested Sludge Disposal on Crop Land," Journal WPCF, May, 1969, Part 1.

7. McCarty, P.L., "Sludge Concentration-Needs, Accomplishments and Future Goals," Journal WPCF, April, 1966.

8. Schwartz, W. A., and Bendixen, T. W., "Soil Systems for Liquid Waste Treatment and Disposal: Environmental Factors," Journal WPCF, April, 1970.

SOLID WASTE DISPOSAL

GENERAL DISCUSSION

Disposal of solid wastes or refuse is a problem of increasing urgency as the population grows, as the amount of waste per capita becomes rapidly larger, and as suitable landfill sites become scarcer and more expensive near urban areas such as the Dallas-Fort Worth Metropolitan area. Fire and smoke, increasing numbers of rodents and insects, and pollution of air, ground and water supplies are some of the obvious effects of the improper disposal of refuse. In 1969, Senate Bill 125 was passed by the Texas Legislature, which gives the Texas State Department of Health local governments the authority to control solid waste disposal. Also in 1969 the Texas Legislature passed House Bill 1367 which authorized Commissioners Courts of Counties to acquire, construct, improve, equip, maintain, finance, and operate solid waste disposal facilities. This Act further granted to the Commissioners Courts the power to promulgate all reasonable regulations and rules applicable to the usage of such disposal facilities.

Refuse is generally defined as being all of the solid wastes of a community from domestic, municipal, commercial and industrial sources including those semi-liquid or wet wastes whose moisture content is insufficient to make the material free flowing (it may also include hazardous liquid wastes). Refuse may be classified into four categories: garbage, rubbish, ashes and special wastes. Garbage consists of putrescible wastes derived from the preparation, cooking and serving of foods; from their handling, storage in slaughterhouses, canneries and quick-freeze industries; and from their handling and storage in transport units and warehouses. Rubbish consists of nonputrescible wastes of a combustible and/or non-combustible character normally produced by the community. Typical combustibles are paper, wood and cloth products; rubber, leather and synthetic products and garden wastes. Typical non-combustibles are metals, metallic and certain plastic products, stones and dirt, masonry, ceramic and glass products. Ashes consist of residue, including cinders and fly ash, from burning solid fuels for cooking and heating, and from on-site incineration of refuse materials. Such non-combustible materials may constitute from 15 to 35 percent by weight of the refuse as received. Special wastes include the following:

(1) Street refuse-sweepings, litter, leaves and dirt;

(2) Demolition and construction-lumber, masonry, plaster, piping, conduits, roofing and insulation, excavated dirt and stone;

(3) Dead animals-cats, dogs, rodents, birds, fish, cattle, horses and zoo specimens;

(4) Out sized wastes-abandoned vehicles, stoves and refrigerators, over-large furniture, tree trunks and stumps;

(5) Sewage treatment removals-screening, grease and scum, grit, dewatered or dried sludge;

(6) Anatomical and pathological wastes from hospitals, clinics and medical centers;

(7) Industrial (usually self-disposed). These are almost limitless. They range from the quite common cinders and fly ash from power plants to highly specialized wastes of specific industries. They include various hazardous chemicals and chemical by-products, paints, explosives, and radioactive wastes;

(8) Miscellany-trees, rubber tires, various plastic materials, cemetery floral pieces.

Total and per capita refuse production is rising at an increasing rate. It is reported that per capita refuse generation in some locations has increased from 2.5 lb per day fifteen years ago to about 5 lb per day at present. It is expected to continue to increase at a rate of at least 2 percent per year. The estimated annual solid waste production of the 2,690,000 people now living in the North Central Texas region is thus about 2,450,000 tons (or 6,700 tons per day). The packaging industry is conscious of the need to reduce disposal problems associated with current packaging materials, and it is hoped that changes can be made to reduce the rate of increase. In addition, the effect of the Dallas-Fort Worth Regional Airport on solid waste production and disposal must be considered.

PUBLIC HEALTH ASPECTS

Disease-producing agents fall into two categories; biological agents and chemical agents. In the instance of biological agents, the U.S. Public Health Service reports that solid wastes are a possible source of disease in the United States. Although the actual incidence of disease due to solid wastes alone is not known (estimates are made from known modes of transmission), it is reported to be significantly higher in certain groups, particularly those without general sanitation including proper solid waste disposal means. The diseases considered to result from improper solid waste disposal are infectious (biological) in nature, no relationship having been established for non-communicable disease agents because of lack of data. Regardless of the lack of specific data, it appears logical that the transmission of disease, whether by direct contact, vector contact or indirect contact, may be attributed in part to the environment being contaminated by solid wastes. Thus, the proper disposal of solid wastes is of public health significance. The known ability of flies to proliferate enormously in organic wastes, to contaminate themselves with fecal wastes, and then to contaminate man and his environment, incriminates the fly as a major health hazard. Flies are proven carriers of many disease agents, and fly-control experiments indicate that they are significant transmitters of shigellosis (bacillary dysentery). A definite factor of disease transmission must be the domestic fly population which is largely regulated by the breeding opportunities afforded and which in turn can be controlled by the solid waste disposal practices of an area.

The importance of solid wastes to mosquito-borne disease such as malaria is less clear than in the case of the fly. The relative contribution of mosquitoes bred by means of solid waste consituents such as water filled cans as opposed to that of mosquitoes bred by other means, has not been studied. The inference to be drawn from available information is that, under certain circumstances, the presence of breeding places provided by solid wastes could contribute to dissemination of a disease agent in a human population, although to an unknown degree.

Rats breed in, or are attracted to, food wastes and can propagate in large numbers where food wastes and harborage are available. Certain species of rat and other rodents have been shown to carry and transmit disease agents infectious for man, such as cholera and plague. Considering the adaptability of the rat, the numerous sources of food other than wastes, and the obscurity of its contribution to human disease incidence, the relative importance of solid waste toward this contribution is equally obscure. However, the fact that there is a positive disease association, and that the rat is a dangerous enemy to man in other areas, have been made evident. In addition to mosquitoes, flies and rats, roaches and ants abound in solid waste disposal areas and may also transmit disease agents to man. Biological agents found in solid wastes include pathogenic bacteria, viruses, fungi, protozoan cysts, and helminth eggs.

Chemical disease-producing agents are becoming more and more important because of the increasing quantities and varieties of chemicals requiring handling and disposal. Two types of chemicals are of special concern; carcinogens (cancer producing substances) and pesticides. Carcinogens have been reported found in water supplies contaminated by either liquid or solid wastes (although specific instances of this in the NCTCOG Area are not known). Pesticides may be toxic to humans and have long-term effects as yet undetermined.

A 1967 literature survey entitled "Solid Waste/Disease Relationships" prepared for the U.S. Public Health Service indicated that there is a continuing need to catalog specific agents (biological and chemical) and components of solid wastes which may offer potential hazards because of the changing nature of solid wastes over a period of years.

METHODS OF DISPOSAL

Growing population and density around metropolitan areas result in a greater number and concentration of refuse disposal sites. The problem of where to locate refuse disposal sites and what method of disposal to employ is of great concern to NCTCOG, the Texas Water Quality Board and other State and Federal agencies because of the potential threat posed to the quality of surface and underground waters. In the study area there are a number of water-bearing aquifers providing water for domestic and industrial purposes, although a major proportion of the water supply is taken from surface reservoirs as discussed in Chapter II.

Traditional open burning and non-burning dumps are no longer acceptable methods for the disposal of solid wastes because of their unhealthy and unsightly nature. This condition is especially true in a rapidly urbanizing area with decreasing areas of available remote vacant land and with stricter air pollution control requirements. A recent study of dump grounds and sanitary landfills in Tarrant County by the Texas State Department of Health recommends:

> 1. Some of the presently used dumps are filled to capacity and should be closed.
>
> 2. All operating disposal sites should be maintained as sanitary landfills with continuous compaction of refuse and daily earth cover.
>
> 3. Al[illegible]ing operations at dump grounds should be discontinued at once.

4. A single county agency should be responsible for solid waste management.

5. *Long-range studies should be made of the solid waste disposal needs of the county and the North Central Texas Region. Following such a study, the creation of a multi-county waste disposal authority might be considered and carried out.*

Most cities in the North Central Texas region are utilizing the sanitary landfill method of disposal. However, the extent to which water pollution may be resulting from the operation of these landfills has not been determined. A sampling program of waters in the vicinity of such landfills should be undertaken to determine if such pollution is indeed occurring. If significant water pollution is occuring from a landfill, corrective measures such as diking or otherwise isolating the site from surface and ground waters should be carried out, as discussed hereinafter. In suburban and rural areas a properly operated sanitary landfill is usually the most economical of several acceptable disposal methods. However, land areas suitable for sanitary landfill are becoming more and more difficult to find. Three acceptable solid waste disposal methods are sanitary landfill, composting and incineration.

Sanitary landfill is a controlled method of refuse disposal in which refuse is deposited on aprepared area of impervious material(clay)and compacted, and then at the end of each day covered with at least a 6-in layer of compacted granular fill. Thus, each day's refuse is enclosed in a cell, preventing ready access by rats and insects. Relatively extensive areas of land are required for landfills. The useful life of landfills can be extended by baling and compressing the refuse. Water supply must be available at a landfill site, and the movement of surface and ground water must be controlled as discussed hereinafter. Disposal of landfill is estimated to cost from about $1.50 to $3.50 per ton depending on size. Total cost for handling baled and compressed refuse in a sanitary landfill would be from $6 to $8 a ton. Landfills can result in land reclamation for parks, golf courses, etc., when properly completed.

Composting of refuse is a process in which rubbish and garbage are placed in specially designed containers and under controlled conditions of mositure and temperature are allowed to biologically decompose over a period of eight days to twenty days depending on the method used. The material becomes a relatively inert and odorless humus and then is suitable for use as a soil conditioner, but a market for such material is frequently not available. Water supply is necessary at a composting site, and surface and groundwater must be controlled to prevent pollution of near-by water courses. Composting has been tried in Houston, Texas, but for economic and aesthetic reasons has not been a great success to date. However, compost has value as a soil conditioner and as such could have considerable value in agricultural areas. Furthermore, compost could be disposed of to landfills, thus lengthening the useful life of the landfills by perhaps 50 percent.

Incineration is a proven and acceptable method of refuse disposal, but is the most expensive because of the complex equipment required. A properly designed and operated incinerator will eliminate odors and reduce air pollution to acceptable standards, and it reduces the land area required for disposal. Modern specifications commonly require less than 5 percent organic and less than 0.2 percent putrescible

matter in the residue. Total cost for an incinerator to handle 1,600 tons per day would be about $10 per ton. Air pollution control requirements are resulting in greatly increased construction costs for incinerators. Adequate water supply and facilities for ash disposal must be available and an incinerator should be served by a sanitary sewer. Recent studies indicate that pathogenic organisms may survive in significant numbers in incinerator residues. However, proper sanitary landfill disposal of the residue can prevent these surviving organisms from becoming a public health problem.

Other Methods of Disposal. Other methods of solid waste disposal which are under study or in limited use are listed below:

1. Compressing and Baling - This method involves compressing ordinary refuse to a volume roughly equivalent to incinerator residue and baling the compressed material. Bales may be buried or used as building blocks, but gases generated by organic material within the blocks appear to have made this an impractical and even dangerous practice. Underground salt domes may possibly be used as disposal sites for high density bales containing very low voids.

2. Burning and Compressing - This method involves incineration of the refuse and compressing the residue into building blocks.

3. Transport - The rail haul of solid waste to disposal sites located at some distance from the metropolitan area has been studied and found economically attractive in the San Francisco and Philadelphia areas. However the reluctance of outlying communities to receive the wastes has thus far prevented this method of disposal from being carried out.

4. Pyrolization - This method involves the destruction of refuse by heat and without air, but it does not result in significant volume reduction.

5. Melt-zit Destructor - This proprietary system will burn all refuse from wet garbage to engine blocks at high temperature. Volume of waste may be reduced to about 5 percent of that of the original refuse.

6. Destructible Materials - Efforts are now underway by manufacturers to develop methods of making their products more disposable, i.e. self-destroying glass and plastic containers and chemicals to dissolve plastics.

7. Reclamation - Efforts are now underway to reclaim materials such as aluminum cans and automobile metals from refuse.

8. Reuse - Many managers believe that the only lasting solution for the solid waste disposal problem lies in the recycling and reuse of wastes. Since our natural resources may neither be created nor destroyed, they should be, to the greatest extent attainable, reused to complete the cycle. Although the reprocessing system might cost more than the direct disposal of the waste, the ultimate value of reuse might prove to be the most economical solution. Efforts are now underway to use processed solid wastes for such uses as highway pavement, fertilizer, and building blocks.

At the ASCE Specialtiy Conference on Power in 1968, it was suggested that electric utilities examine the use of refuse as a fuel. Increasingly strict air and water pollution control requirements are factors suggesting that serious consideration be given to waste heat recovery for steam and/or power generation.

In 1967 the Texas Electric Service Company studied the possibility of burning refuse at the City of Odessa, Texas to produce steam or power. It was found that the cost of operating a dual-purpose plant would equal or exceed the value of the steam or power it produced, so the cost of the plant itself would have to be paid by those wanting to dispose of their wastes.

If it is assumed that 30 kilowatts (kw) of power can be produced from a ton of refuse and all solid waste from the study area (6,700 tons per day) could be burned in a central plant, as much as 200,000 kw of power might be produced at present. By 1990 power production from this source would increase to about 400,000 kw. A separate power plant of this size would be comparable in cost per kilowatt to the larger power units (400,000 to 600,000) which are built today. If the refuse could be burned in a large plant whose primary fuel was gas this method of disposal might become more economical than other methods. The generation of electric power using refuse as a fuel and reclaimed sewage effluent for cooling water should, in our opinion, be explored in detail. The use of reclaimed sewage effluent is discussed earlier in this chapter. An additional fuel source for such a power plant might be excess sludge gas produced by digestion at sewage treatment plants.

The United States Department of Health, Education and Welfare is currently supporting a Solid Wastes Program which includes a research and development program for new and improved methods of proper and economic solid waste disposal; and assistance, both technical and financial, to appropriate agencies in the planning and development of solid waste disposal programs. The Solid Waste Program develops and disseminates technical manuals, standards and guidelines concerning design and operation of incinerators and sanitary landfills. Model State statutes are also being developed in Connecticut and Pennsylvania for effective solid waste management.

Planning grants of up to two-thirds of project costs are awarded to public and non-profit agencies only for solid wastes management. Research grants are awarded to agencies for studies directed toward possible solutions or are for the purpose of gaining information on a wide variety of solid waste problems. Grants for demonstrations, studies and investigations are supporting projects to investigate the feasibility and prove the performance of unusual and innovative engineering techniques and devices, as well as to demonstrate improvement in the more conventional methods of solid waste disposal. It is becoming evident that much more attention should be given in the future to the reduction of solid wastes at their source and to the recycling and reclamation of valuable materials.

EFFECT OF LEACHING ON WATER SUPPLIES

Whether solid waste disposal is accomplished by means of sanitary landfills, composting or incineration, the leaching of the wastes or residue into water supplies may occur. The leaching of landfills, however, is of greatest importance in the pollution of ground and surface waters.

An important factor at disposal sites is the possibility that disease-producing agents may migrate through the soil as a result of leaching and movement of ground water, and pollute water supplies. This leaching process appears to be a more important problem for chemical contaminants than for organisms because of natural mortality and/or removal of viruses and cells by filtering processes. Water treatment processes generally will remove pathogenic organisms, but some toxic chemicals may not be removed.

Leaching occurs in several ways. Groundwater may continually or intermittently wet the bottom of the landfill depending on changing groundwater levels. The flow of surface drainage may pass through or around the landfill thus saturating it. In areas where the groundwater table is generally well below the ground surface and fill material would not be in direct contact with groundwater, pollution could occur as the result of precipitation and surface runoff percolating down through the material into the groundwater.

The California State Water Pollution Control Board published in 1954 a report on the leaching of a sanitary landfill which stated that:

> "A sanitary landfill, if so located as to be in an intermittent or continuous contact with groundwater, will cause the groundwater in the immediate vicinity of the landfill to become grossly polluted and unfit for domestic or irrigational use. It may be expected that continuous leaching of an acre foot of sanitary landfill will result in a minimum extraction of approximately 1.5 tons of sodium plus potassium, 1.0 tons of calcium plus magnesium, 0.91 tons of chloride, 0.23 tons of sulfate and 3.9 tons of bicarbonate. Removals of these quantities would take place in less than one year. Removals would continue with subsequent years, but at a very slow rate. It is unlikely that all ions ever would be removed."

Grover H. Emrich, Groundwater Geologist at Penn State University has studied the generation of leachate and its subsurface movement and recently reported:

> "Maximum initial leachate concentration is characterized as 100 times stronger than raw sewage with BOD of greater than 20,000 mg/1, COD greater than 50,000 mg/1 iron greater than 1,000 mg/1, and chloride greater than 2,000 mg/1. Pollutants are partially renovated as leachate moves down through the subsurface. At a depth of 2 feet below a test landfill, the leachate front had a BOD of 3,400 mg/l iron 200 mg/1, and chloride of 1,900 mg/l. Six months later when the front reached a depth of 12 feet the leachate was still stronger than raw sewage; could still cause a groundwater pollution (BOD 910 mg/1, iron 20 mg/1, and chloride 500 mg/1").

It is evident that landfills are in continuous contact with ground and/or surface water unless properly constructed.

PROTECTION OF GROUNDWATER AT LANDFILLS

Even where public water supply is not endangered, water should be excluded from landfills to the maximum practical extent to minimize the possibility of water pollution. The services of an engineering geologist should be employed before using

any landfill site to assure that subsurface conditions will not permit contaminants to leach into surface or groundwaters. Such a precaution is considered important because leaching, once begun, may continue for many years.

It has been suggested that old gravel pits be utilized for landfill purposes. Since almost without exception gravel operations are confined to stream and river valleys which are also the sites of most alluvial well development, careful consideration should be given before utilizing them.

It is obviously impractical to exclude all water from landfills constructed in marshes of flood plains. Such fills however should be protected by impervious perimeter dikes of earth which will minimize erosion of the fill and leaching of pollutants into adjacent waters. Impervious clay lined cells may also be effective in preventing or minimizing leaching. Chemicals of toxic nature should not be placed in the fill as they may percolate into groundwater.

The following regulations are based on the Public Health Code of the Connecticut State Department of Public Health and similar regulations should be considered for the North Central Texas region:

a. Refuse at a refuse disposal area shall be thoroughly compacted and covered daily.

b. Refuse should not be deposited less than 50 feet away from the high water mark of a watercourse. (Sites should not be located in flood plains or swamps.)

c. At least two feet of clean fill or natural ground (preferably impervious) must be maintained above high groundwater.

d. At least four feet of clean fill or natural ground (preferably impervious) must be maintained over rock.

e. A sanitary landfill must be at least 500 ft from a small private well water supply. (This requirement may be reduced to 300 ft if it can be shown that groundwater flow is and will be away from the well.)

f. Supervision of a landfill at all times of operation is a requirement. (This is a protection against improper dumping of the chemicals and unwanted wastes mentioned above).

For a metropolitan area to meet the above requirements is difficult, but unless they are achieved consistently throughout the North Central Texas region, greater pollution of surface and groundwaters is sure to result.

Groundwater pollution sources are difficult to trace and may ruin an aquifer for years, or permanently. This potential indicates a real need to examine solid waste disposal techniques and sites to assure that leaching will not produce public health problems. The problem is one of water pollution–no matter what the source. Once the pollutant is in the water, it may never be known whether it entered the water originally as liquid or as solid waste.

CONCLUSIONS

In conclusion, a properly constructed and operated sanitary landfill is a satisfactory and economical method of solids waste disposal, and it will not create problems of public health or water quality. A sampling program should be undertaken in the vicinity of existing landfill sites to ascertain the extent to which water pollution is now being caused by solid waste disposal operations. Following such a program remedial measures should be taken to eliminate the long-term leaching of polluting substances into nearby water courses.

Inasmuch as solid waste disposal is a regional problem, not confined to county jurisdiction, it is recommended that all rules and regulations administered by counties should be coordinated through a regional agency to assure the maintenance of uniform requirements and standards of construction and operation. With the assistance of the Texas State Department of Health, cities and counties of the North Central Texas region through the regional agency, should consider developing a model solid waste disposal ordinance.

ACKNOWLEDGEMENTS

We wish to acknowledge the assistance received from the NCTCOG Ad Hoc Committee on Solid Wastes in the preparation of this section on solid waste disposal. Members of that committee to whom we make particular acknowledgement, are Mr. Howard R. Drew, P. E., Director of Research, Texas Electric Service Company; Mr. Lee S. Vickers, City Manager, City of McKinney, Mr. H. E. Drumwright, Assistant Director of Public Works, City of Dallas; Mr. L. D. Thurman, P. E., Director of Environmental Health, Dallas County; Mr. William F. Cox, R. S., City Sanitation, Garland; Mr. I. W. Santry, Jr., P. E. Consulting Engineer. In addition, we acknowledge the constructive comments of the Texas State Department of Health and the Texas Water Quality Board.

REFERENCES

1. Andersen, J.R. and Dornbush, J.N., "Influence of Sanitary Landfill on Ground Water Quality," Journal, American Water Works Association, April, 1967.

2. Anderson, R.J., "The Public Health Aspects of Solid Waste Disposal," Public Health Reports, Feb., 1964.

3. Brown, S. "Garbage as Fuel," Engineering News-Record, Aug. 7, 1969.

4. Commonwealth of Pennsylvania, Department of Health, "Act 241, Pennsylvania Solid Waste Management Act," S/W Publication I, Aug., 1968.

5. Cummins, R.L., "Effects of Land Disposal of Solid Wastes on Water Quality," National Center for Urban and Industrial Health, Solid Wastes Program, Cincinnati, Ohio, 1968.

6. Drew, H.R., "The Production of Steam or Power through the Incineration of Municipal Wastes," Texas Electric Service Company, Nov., 1967.

7. Emrich, G.H., and Landon, R.A., "Generation of Leachate from Landfills and its Subsurface Movement," Bureau of Sanitary Engineering, Pennsylvania Department of Health, Harrisburg, Pa., 1969.

8. Engineering News-Record, "Solid Waste Train Idea Derails," Aug. 14, 1969.

9. Engineering News-Record, "Solid Wastes Pile Up While Laws Crack Down and Engineers Gear Up," June 12, 1969.

10. Gazda, L.P. and Malina, G.F., Jr., "Land Disposal of Municipal Solid Wastes in Selected Standard Metropolitan Statistical Areas in Texas," Environmental Health Engineering Research Laboratory, EHE-69-13., Univ. of Texas, Austin, Texas, April, 1969.

11. Hanks, T.G., "Solid Waste/Disease Relationships; A Literature Survey," Public Health Service Publication No. 999-UIH-6, U.S. Government Printing Office, Washington, 1967.

12. Hughes, G.M., Landon, R.A., and Farvolden, R.N., "Hydrogeology of Solid Waste Disposal Sites in Northeastern Illinois; An Interim Report on a Solid Waste Demonstration Grant Project," U.S. Department of Health Education and Welfare, 1969.

13. Merz, R.C. and Stone, R., "Progress Report on Study of Percolation Through a Landfill," Public Works Magazine, Dec., 1967.

14. National Association of Counties Research Foundation, "Solid Waste Management," Volume 1-9.

15. "Proceedings–National Conference on Solid Waste Research," American Public Works Association, Chicago, Illinois, 1963.

16. "Proceedings of 1961 Symposium–Ground Water Contamination," Technical Report W61-5, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, 1962.

17. Schroering, J.B., "Sanitary Landfilling–Applications and Limitations," Pollution Engineering, October-November, 1969.

18. Schroering, J.B., "Solid Wastes Processing and Reclaiming," Pollution Engineering, March–April, 1970.

19. "Solid Waste Management–A List of Available Literature," U. S. HEW, Dec., 1969.

20. State Water Pollution Control Board Publication No. 2, "Report on the Investigation of Leaching of Ash Dumps," Sacramento, California, 1952.

21. State Water Pollution Control Board Publication No. 10, "Report on the Investigation of Leaching of a Sanitary Landfill," Sacramento, California, 1954.

22. State Water Pollution Control Board Publication No. 24, "Effects of Reuse Dumps on Ground Water Quality," Sacramento, California, 1961.

23. Texas Municipal League, "Refuse Collection and Disposal Practices," Austin, Texas, Oct. , 1965.

CHAPTER XII

ADMINISTRATION OF RECOMMENDED PLAN

AUTHORITY OF EXISTING GOVERNMENT AGENCIES

GENERAL

Pollution abatement of the North Central Texas area waters fall within the authority of many governmental agencies, Federal, State and local. The authorities and responsibilities of the various agencies frequently overlap and centralized (regional) authority is lacking. The authorities and responsibilities of the various existing agencies are discussed briefly herein as they may affect the control of pollution within the study area.

FEDERAL AGENCIES

Department of the Interior. The Department of the Interior is the Federal agency with the greatest overall responsibilities in the field of water resources. These responsibilities were greatly augmented in May, 1966 by the transfer to the Department of the Interior of the Federal Water Pollution Control Administration, now the Federal Water Quality Administration (FWQA), from the Department of Health, Education and Welfare. The FWQA, under the Federal Water Pollution Control Act, Public Law 84-660, as ammended by the Water Quality Act of 1965, administers a national program to enhance the quality and value of the nation's water resources and to otherwise assure the fulfillment of a national policy for the prevention, control, and abatement of water pollution. In accordance with the Act the State of Texas has adopted water quality standards as discussed in Chapter III.

Guidelines supporting the requirements of the Federal Water Pollution Control Act are,in part, as follows:

1. Standards of quality established pursuant to this subsection shall be such as to protect the public health or welfare, enhance the quality of water and serve the purposes of this Act.

2. The discharge of matter into such interstate waters or portions thereof, which reduces the quality of such waters below the standards established under this subsection is subject to abatement in accordance with the provisions of the Act.

3. Economic, health, aesthetic, and conservation values which contribute to the social and economic welfare of an area must be taken into account.

4. Water quality standards would provide an engineering basis for design of treatment works by municipalities and industries.

5. Water quality standards are not designed for use primarily as an enforcement device but rather to provide the orderly development and improvement of our water resources.

In addition to the above guidelines, the FWQA has adopted a policy which allows no "waste amenable to treatment or control to be discharged into any interstate water without treatment or control regardless of the water quality criteria and water use or uses adopted". Furthermore, such wastes must receive the "best practicable treatment or control" unless a lesser degree of treatment can be shown sufficient.

Among the major functions of the FWQA are:

1. The development of procedures for comprehensive and special programs designed to eliminate or reduce the pollution of interstate waters and their tributaries.

2. The encouragement and cooperative support of State enforcement authorites and exercise of Federal authority as required to abate pollution of interstate or navigable waters.

3. The encouragement of the development and enactment of improved State laws and the development of interstate compacts.

4. The conduct, promotion, and support of research investigations, experimentation, and demonstrations, including the publication of related results and information.

5. The awarding of grants for the construction of municipal waste treatment works as discussed hereinafter.

6. The awarding of grants and utilization of contract authority to assist in demonstrating new or improved methods for controlling pollutional waste discharge from combined sewer systems.

In addition to the FWQA, the Department of the Interior also has within its jurisdiction the United States Fish and Wildlife Service. This service, in promoting fisheries resources, has a leading interest in water pollution control, water supply projects, and determination of benefits from the standpoint of fish and wildlife.

Department of Housing and Urban Development. One of the purposes of the Housing and Urban Development (HUD) Act of 1965 (Public Law 89-117) is to encourage cities to construct adequate water and sewer facilities to promote the efficient and orderly growth and development of urban areas. Grants may be made to public bodies and agencies to finance specific projects for water and sewage works other than sewage treatment works for which grants are available under Federal Water Pollution Control Act.

To be eligible for assistance requires showing that an individual project is or will be consistent with the short-range, area-wide planning. Water and sewer systems must not only be planned jointly, but must also be appropriately related to other urban area systems, such as transportation or open space and recreation. Most of the planning and programming activities covered can be assisted under HUD's Section 701 planning assistance program.

HUD administers the National Flood Insurance Act of 1968 (Public Law 90-448) as amended, which provides for underwriting flood damages in flood prone residential areas. It requires cities to establish zoning of flood plains by December 31,1971.

Department of Agriculture. Under the Consolidated Farmers Home Administration Act of 1961, as amended, (Public Law 89-240) grants for the planning and construction of water supply systems and waste disposal works are provided to aid rural community development in accordance with comprehensive overall plans for area-wide development of such facilities.

The Soil Conservation Service is concerned with the effect of land and water resources on the agricultural economy of the Upper Trinity River Basin. It is actively implementing a Watershed Improvement Program for flood prevention, sediment control and water management under the authorities of the Flood Control Act of 1944 (Public Law 78-534) and the Watershed Protection and Flood Prevention Act of 1954.

Department of Defense. The Secretary of the Army is responsible for the civil works program of the Corps of Engineers, which includes such activities as waterways improvements, flood protection, water supply, river flow regulation, hydroelectric power, shore protection, recreation, and regulation of use of navigable waterways.

The Corps prepares reports on flood information in various watersheds, when requested by appropriate local and State agencies, under the authority of the Flood Control Act of 1960 (Public Law 86-654).

The Corps of Engineers was authorized and did prepare a "Comprehensive Survey Report on Trinity River and Tributaries, Texas" in 1962 which recommended a project encompassing flood protection, water supply, flow augmentation, navigation and recreation on the Trinity River as discussed in Chapter III. Authority for the investigation derived from a number of Congressional resolutions and Section 112 of the Rivers and Harbors Act of 1958.

The Rivers and Harbors Act of 1945, the Flood Control Acts of 1954, 1960, 1962 and Public Law 86-399 authorized the construction of a number of projects (dams,floodway extensions, channel improvements, etc.) which form part of the comprehensive river plan. The Corps exercises control over water releases from and development of its reservoirs.

Department of Health, Education and Welfare. The U.S. Public Health Service is under the Department of Health, Education and Welfare (HEW) and it retained some responsibility for water pollution control after the transfer of the Federal Water Pollution Control Administration (now the FWQA) to the Interior Department as discussed above. The Public Health Service continues to have broad responsibilities for environmental health activities, including conduct of research, techniques and methods of control, development and utilization of manpower, and administration of regulations for public health as it may be affected by environmental pollution.

The Solid Waste Disposal Act of 1965 (Public Law 89-272) is administered by HEW. This act authorizes grants and aid to local, state and interstate agencies for research, technical training and demonstration projects as discussed in Chapter XI.

Department of Commerce. The Economic Development Administration (EDA) was established under the Secretary of Commerce by the Public Works and Economic Development Act of 1965 (Public Law 89-136). This Act provides grants for public works including water and sewer facilities when they contribute to the economic development of eligible depressed areas.

Federal Installations. Two large Federal installations within the study area have responsibilities with regard to sewerage; the Federal Correctional Institute at Seagoville and the Dallas Naval Air Station in Grand Prairie. The Federal Correction Institute currently operates and maintains its own sewage collection and treatment system. A study currently is being made to phase out the institute's treatment plant and pump sewage into the city of Seagoville sewerage system. The Dallas Naval Air Station sewage treatment plant was deactivated in 1968 when rights in the TRA Central Sewerage System were obtained.

STATE OF TEXAS AGENCIES

Texas Water Quality Board (Article 7621d, et seq, Vernon's Annotated Civil Statutes of Texas, as amended by Senate Bill 147). Formerly known as the Texas Water Pollution Control Board, the TWQB, assisted by member agencies through their Austin offices and field staffs, is principal authority in Texas in water quality matters. The specific functions relating to the programs of the Texas Railroad Commission, the Texas Water Development Board, the Texas Parks and Wildlife Department, and the Texas State Department of Health are coordinated with the programs of the TWQB.

The TWQB has the power to administer the Texas Water Quality Act, establish the level of quality to be maintained and control the quality of the waters of the State. To accomplish this purpose the TWQB issues orders requiring the abatement of pollution from any source. It also issues permits for the discharge of waste into or adjacent to the water in the State as discussed in Chapter VIII and hold public hearings. The TWQB also controls or prohibits the use of septic tanks as discussed in Chapter IV.

The TWQB is authorized to execute agreements with the Department of the Interior and other Federal agencies that administer pollution control programs. It is also authorized to make grants and loans for the construction of treatment works, but funds have not been made available for this purpose. In addition, the TWQB may make grants or interest-free loans to or contract with local governments, regional planning commissions and planning agencies for developing effective, comprehensive water quality control and pollution abatement plans. This report is, in part, financed by the TWQB.

Texas State Department of Health (Article 4414a, et seq, Revised Civil Statutes of Texas). The duties of the TSDH relate to the public health aspects of water. It is also represented on the Texas Water Quality Board. The duties of the TSDH were not affected by Senate Bill 147, an Act which amended the Texas Water Quality Act of 1967. Its duties are spelled out in Chapter 234, Acts of the 49th Legislature, 1945 as amended. It makes recommendations to the TWQB in all matters related to water quality.

The TSDH is active in all phases of public health work on the State level through development of standards, issuance of regulations, etc. On the local level it works through its various district offices, works with and through local City and County Health Departments. Its services include routine laboratory testing for the smaller municipalities unable to provide these services for themselves. An important field that the TSDH is active in is the training, education and general upgrading of technical and operating personnel in water works and waste treatment plants.

Texas Water Development Board (Article 8280-9, Vernon's Annotated Civil Statutes of Texas). The TWDB, represented on the Texas Water Quality Board, is charged with the statewide investigation of the quality and use of surface water and groundwater. The powers and duties of the TWDB, unaffected by Senate Bill 147, are specified in Chapter 82, Acts of the 57th Legislature, Regular Session, 1961, as amended (Article 762lb, Vernon's Texas Civil Statutes). The TWDB, along with the Texas Water Well Drillers Board, continues to exercise the authority granted to it in Chapter 264, Acts of the 59th Legislature, Regular Session, 1965 (Article 7621e, Vernon's Texas Civil Statutes).

The TWDB has developed a master water plan for Texas, as discussed in Chapter III. It participates with Federal agencies in planning resource developments, and participates in the financing of water projects through the Texas Water Development Fund, presently authorized by the Constitution at $400,000,000.

Texas Railroad Commission (Article 742ld, Sec. 10 (c) (4), Annotated Civil Statutes of Texas). The Texas Railroad Commission, represented on the Texas Water Quality Board is solely responsible for the control and disposition of brine produced in oil and gas field operation, and of related pollution. The TRC may issue permits for the discharge of waste resulting from such operations. Discharge of such waste into any water in the State must meet the water quality standards established by the Texas Water Quality Board. The powers and duties of the TRC, unaffected by Senate Bill No. 147, are specified in Chapter 82, Acts of the 57th Legislature, Regular Session, 1961, as amended (Article 762lb, Vernon's Texas Civil Statutes).

Texas Water Rights Commission (Article 7477, et seq, Vernon's Annotated Civil Statutes of Texas). The Texas Water Rights Commission is responsible for supervising the operation of local and regional water agencies and for protecting the public interests and individual property rights in water development and use. The Commission's authority includes the administrative adjudication of water rights. Public hearings on proposed Federal projects are held by the Commission, which provides comments to the Governor on those proposals. It also designates local sponsors on projects to be constructed by a Federal agency.

Texas Soil and Water Conservation Board (Article 165a-4, et seq, Vernon's Annotated Civil Statutes of Texas). The Conservation Board's program includes upstream watershed flood retardation, erosion prevention, agricultural drainage, and related programs. Reservoirs constructed under the upstream flood prevention program may include storage capacity for municipal, industrial, irrigation and recreation purposes. The Board cooperates with the local soil and conservation districts and the U.S. Soil Conservation Service.

Texas Parks and Wildlife Department (Article 978f-3A, Vernon's Annotated Penal Code of Texas). The responsibilities of the Parks and Wildlife Department (P&WD) relate to wildlife, to fisheries in streams, bays, and the Gulf of Mexico, and to recreation. The P&WD, in the same manner as the Texas Water Quality Board, may cause suit to be instituted in a district court for injunctive relief, civil penalties, or both, against a person violating any provision of Section 4.01 of Senate Bill No. 147, or any rule, regulation, permit or other order of the TWQB that particularly affects aquatic life or wildlife. Within the NCTCOG area, the development of major reservoirs has four effects upon the programs and responsibilities of the P & WD:

1. Demand for recreational facilities

2. Improved fisheries

3. Loss of wildlife habitat

4. Possible impacts on downstream bays and estuaries

The Parks and Wildlife Department is represented on the Texas Water Quality Board.

The Interagency Natural Resources Council was created by H.B. 276 of the Sixtieth Legislature. P.L. 90-454 directed the U.S. Department of the Interior to undertake a Texas Estuarine (Conservation) Study which has now been re-named the Coastal Resources Management Program. The function of the INRC as set forth in the Senate Resolution is to make a comprehensive study of the state's submerged lands, beaches, islands, estuaries, and estuarine areas, including but without limitations coastal marshlands, bays, sounds, seaward areas, and lagoons. The purpose of the study is to insure an orderly development of the coastal region, keeping in balance preservation of the natural beauty and resources with that of commercial utilization of the area.

The Council is chaired by the Governor and composed of the Executive Directors of the participating member agencies; however, it is not a part of the Governor's Office, but a separate political entity of Texas State Government. It is to submit on or before December, 1970, to the Governor and to the Legislature a progress report indicating the status of its studies to date, together with any recommendations for emergency legislation, with a final report to be submitted on or before December, 1972. The final report is to make recommendations for appropriate legislation to carry out the purposes of its study. The INRC is operating under a budget of \$200,000.00, which was appropriated by the 61st Texas Legislature, and has the power to contract with or receive aid from state, federal or local public agencies or private agencies. It is to avoid duplication of work and to make the maximum use of all available data from state and federal agencies and the resolution specifically directs all city, county and state officials to make their data available to the INRC without charge. The preliminary planning effort began on March 4, 1969, by the means of a \$10,500.00 interagency contract between the Interagency Natural Resources Council and the Sea Grant Program of Texas A & M University. The scope of this effort is to compile an annotated bibliography of prior studies, studies currently funded and proposed research reports and action programs by federal, state and local governments and by institution, entities and industry within the coastal region. This report is now completed and published.

The present members of the Council are Office of the Governor, General Land Office, Texas Air Control Board, Texas Industrial Commission, Texas Railroad Commission, Texas Highway Department, Texas Parks and Wildlife Department, Texas Soil and Water Conservation Board, Texas Water Quality Board, Texas Water Development Board, Texas Water Rights Commission and Ex Officio Members. An enumeration of the task subjects which will be considered during the planning effort are sociology, economic development, recreation, land use, transportation, water quality, physical dispersion, chemistry, hydrology, biology and ecology, coastal engineering, geology, legal research and systems management.

Although the primary area to be encompassed by the study will be 50 miles inland and 10 miles seaward, it will in effect extend beyond these boundaries because of the areas draining into the study area.

Perhaps the most important effect of the INRC will be its funtion as a state clearing house to review federal natural resources grants to the State of Texas.

Other activities of the Council, in addition to the Coastal Resources Management Program and the State Clearinghouse functions, are the development of a water data information system, formulation of joint procedures for coordination of federally-supported water projects, and preparation of natural resources legislation.

REGIONAL AGENCIES

The North Central Texas Council of Governments was established in 1966 under authority provided by the Texas Legislature (Chapter 570, Article 1011m,Vernon's *Annotated Civil Statutes of Texas*). A voluntary association of 117 local governments, represented by elected officials in the region, the NCTCOG serves the ten-county metropolitan Dallas- Fort Worth Area. It fosters intergovernmental cooperation and coordination,conducts regional planning activities and both complements and supplements local government.

Senate Bill 547, which amended Chapter 570 in 1969, clearly defined and broadened the scope of regional councils and provided Texas COG's with additional State financial assistance for comprehensive regional planning. NCTCOG, as Regional Planning Commission, may make studies and plans to guide the unified, far-reaching development of the area, to eliminate duplication, and to promote economy and efficiency in the coordinated development of the area. It may recommend to cooperating governmental units the programming and financing of projects and facilities needed for such development. The ten county region was recently designated as the air quality control region.

NCTCOG has no powers of enforcement and has no power to levy any character of tax, but it is eligible to receive Federal grants for water pollution control. The participating local governments may appropriate funds to the NCTCOG for the cost and expenses required in the performance of its purposes of planning and recommendation.

Trinity River Authority of Texas. Under Article XVI, Section 59 of the Texas Constitution, the TRA was created as a conservation and reclamation district. It is the governmental agency and political subdivision of the State of Texas specifically created by the Legislature for the purpose of developing the water resources of the Trinity River Basin (limited to river downstream of reservoirs). The portion of the NCTCOG area that lies within TRA boundaries includes all of Dallas, Tarrant and

Ellis Counties, and most of Kaufman County. The portion of Henderson County generally west of Athens, contiguous to the NCTCOG area and lying within the study area, is also within TRA jurisdiction. Remaining areas within the study area do not fall within TRA jurisdiction.

The duty of the TRA is to exercise powers to control floods, conserve soils, provide water supplies to towns, cities and individuals, prevent siltation of lands, channels, reservoirs, and coastal waters, provide irrigation water and provide water for the development of commercial and industrial enterprises. The TRA is to exercise powers to contract with municipalities to construct reservoirs, dams and water supply equipment, to encourage and develop recreational facilities, to preserve fish and wildlife, to regulate and promote the construction and operation of commercial navigation facilities and "to construct, own and operate sewage gathering, transmission and disposal services, to charge for such service and to make contracts, in reference thereto with municipalities and others."

The TRA is authorized "to prepare a master plan for the maximum development of the soil and water resources of the entire Trinity River wastershed, including plans for the complete utilization, for all *economically beneficial purposes*, of the water resources of the watershed. . . . "

The Trinity River Authority may issue revenue bonds by action of its Board of Directors (who are appointed by the Governor) and may issue tax bonds secured by an ad valorem tax limited to fifteen (15) cents on the \$100.00 valuation of taxable property, by a vote of the people residing within the boundaries of the Authority. Furthermore, the TRA may levy and collect such taxes as are voted at an election called by the Board for the purpose, and conducted throughout the territory of the Authority.

To date, the TRA has financed, by contract for services, the construction of facilities for the collection and treatment of municipal sewage, such as the Central Sewerage System, the Ten Mile Creek Sewerage System and the Walker-Calloway Branches Trunk Sewer System. The TRA has entered into agreements with the cities served by these systems. Each city is responsible to the TRA for the character of the effluent which it discharges to the TRA System.

Other River Authorities. Portions of the Brazos, Red River and Sabine River watersheds lie within the boundaries of the study area. Within these other watersheds, the Brazos River Authority, the Red River Authority and Sabine River Authority respectively, have jurisdiction. These authorities are conservation and reclamation districts with responsibilities similar to those of the Trinity River Authority discussed above, and their statutory authority derives from the same legislative Act (Article XVI, Section 59 of the Texas Constitution). However, only the Brazos River Authority has limited power to levy and collect taxes for the purpose of providing sanitary sewerage.

LOCAL AGENCIES

The North Texas Municipal Water District (Article 8280-141 Vernon's Annotated Civil Statutes) is a multi-city district created by the Texas Legislature including the cities of Wylie, Forney, Mesquite, McKinney, Royse City, Rockwall, Plano, Farmersville, Garland and Princeton. The District holds the water rights to the conservation storage

in Lavon Reservoir. Water from the reservoir is treated and transported by the District-owned facilities to the member cities and other customers. The service area of the District includes the area within the East Fork Trinity River watershed, and the area within the corporate limits of the member cities. Under provisions of the Regional Waste Disposal Act, (Article 7621g, Vernon's Annotated Revised Civil Statutes) the District also has the authority to construct and operate regional disposal systems.

The directors, who are designated by the member cities, may make rules and regulations to preserve sanitary conditions and to control all recreational and business privileges in any reservoirs owned or operated. For tax assessment and collection purposes, multi-city water districts are given the same structure and authority as water control and improvement districts created under the general law. Customers may be added by the Board of Directors. Districts must have approval from the Texas Water Rights Commission before proceeding with the construction of dams and diversion works. Each district has the power of eminent domain for dam sites and pipelines, but it is exercised only in counties where member cities are located.

Tarrant County Water Control and Improvement District No. 1 was created in 1924, and operates under the direction of five elected directors. The Water District has broad powers and authority under Article 7880 (Vernon's Civil Statutes of the State of Texas). The District is concerned mainly with water supply for the Fort Worth metropolitan area, with conservation of surface waters, and with flood control. Bridgeport, Eagle Mountain, and Cedar Creek Reservoirs are owned and maintained by the Water District. The Water District and the City of Fort Worth jointly supervise sanitary conditions and possible pollution sources that tend to affect the water quality in these reservoirs. District boundaries for tax purposes consist of approximately 220 square miles, all within Tarrant County. The district is authorized to levy and collect such taxes as necessary within these boundaries to finance and maintain water supply and flood protection facilities.

Commissioners Courts of Counties were authorized by House Bill 1367 in 1969 to acquire, construct, finance and operate solid waste disposal facilities including incinerators, sanitary landfills, etc. For this purpose, the Commissioners Court may issue revenue bonds.

Water Districts are created through special statute by the Legislature or under general statutory authority by Commissioners Courts of Counties, municipal government (in some cases) or the Texas Water Rights Commission. There are presently about 42 water districts within the NCTCOG area. Under Texas statutes districts may be formed for such purposes as fresh water supply, water control and improvement, conservation and reclamation, navigation and underground water conservation. They may be switched from one category to another with broader authority and financial leeway, by a simple majority vote of its board of directors. A "Master Water District" encompassing the entire study area or the NCTCOG region may be established under existing statutes.

Local Governments. The authority of local governments in matters of water quality is specified in Subchapter E of Senate Bill 147 of the Texas Legislature. Principal provisions of this subchapter as they pertain to such matters are as follows:

A. A local government may inspect the public water in its area and determine whether or not:

(1). The quality of the water meets the State water quality standards adopted by the TWQB;

(2). Persons discharging effluent into the public water located in the areas over which the local government has jurisdiction have obtained permits for the discharge of the effluent; and

(3). Persons who have permits are making discharges in compliance with the requirements of the permits.

B. A local government may make written recommendations to the TWQB as to what in its judgement the water quality standards should be for any public water within its territorial jurisdiction.

C. A local government has the same power as the TWQB under this Act to enter public and private property within its territorial jurisdiction to make inspections and investigations of conditions relating to water quality.

D. A local government may bring an enforcement action under this Act for violation of any rule, permit or other order occurring within its area of jurisdiction.

FINANCIAL ASSISTANCE AVAILABLE

The Federal Government provides grants for construction of water pollution control facilities and for research and development as discussed below. The Federal Government also provides grants for the planning, development and conduct of solids waste disposal programs as discussed in Chapter XI. To date the State of Texas has not implemented a program of financial assistance for construction.

In November 1969 the State Attorney General rendered an opinion that Councils of Government legally may receive Federal grants for water pollution control programs. Thus, the NCTCOG is eligible to receive grants for construction of eligible portions of the recommended regional sewerage plan.

FEDERAL GRANT PROGRAMS FOR CONSTRUCTION

Federal grant programs are being carried out by the Departments of the Interior, Housing and Urban Development, and Agriculture. Funds available under each of the programs are presently very limited.

Federal Water Pollution Control Act. (Public Law 84-660, as amended, Department of the Interior). Under amendments to Public Law 660 which became effective July 1, 1967, the Federal grant authorized for either a single or a joint project is 30 percent of the total cost of treatment facilities, interceptors, outfalls, pumping stations, and their appurtenances. If a State agrees to match 30 percent of the total cost, the Federal grant is increased to 40 percent. Furthermore, if a State agrees to pay not less than 25

percent of the total cost, and enforceable water quality standards (classifications) have been established for the waters into which the effluent discharges, the Federal grant will be increased to a maximum of 50 percent (Texas has adopted such standards, and they have been approved by the Federal Water Quality Administration, formerly the FWPCA). An additional 10 percent of any Federal grant may be awarded under this Act for any project that is part of a metropolitan area-wide plan. Since Texas does not provide any State financial assistance, Federal aid is limited to 33 percent of eligible costs. If and when Texas does provide at least 25 percent aid, the maximum Federal grant available under this Act will be 55 percent.

Housing and Urban Development Act of 1965 (Public Law 89-117, Department of Housing and Urban Development). One of the many extensive purposes of this law is to encourage cities to construct adequate basic water and sewerage works in order to promote their efficient and orderly growth. This law provides grants to local public bodies and agencies to finance specific projects for water works and for basic sewer facilities other than sewage treatment plants and interceptors for which grants are available under the Federal Water Pollution Control Act. No grant will be made for a sewage facility until adequate treatment works have been provided. The amount of any grant may not exceed 50 percent of the construction cost of a basic water or sewer facility, but under certain special conditions enumerated in the Act, the amount may be increased for a basic public sewer facility to no more than 90 percent. No grant for either water or sewer facilities will be made unless the Secretary of Housing and Urban Development determines that the project is necessary for the improvements of health and living standard of the people in the community and meets the criteria established by the Department for an area-wide water or sewerage facilities system as part of the comprehensive planned development of the area.

Consolidated Farmers Home Administration Act of 1961 (as amended, Public Law 89-240, Department of Agriculture). Under this legislation, grants for the planning and construction of water supply systems and waste disposal works are provided to aid in rural community development in accordance with comprehensive plans for area-wide development of such facilities. The grants may not exceed 50 percent of the total project cost, and eligibility is limited to rural areas of 5,500 inhabitants or less.

FEDERAL GRANT PROGRAM FOR RESEARCH AND DEVELOPMENT

Under the Federal Water Pollution Control Act, Public Law 84-660, as amended, the Department of the Interior is authorized to make research and development grants to State, municipal, inter-municipal or interstate agencies. Grants of up to 70 percent of the estimated reasonable cost of approved projects may be made for:

1. Assisting in the development of any project which will demonstrate a new or improved method of controlling the discharge into any waters of untreated or inadequately treated sewage or other wastes from sewers which carry storm water or both storm water and sewage or other wastes.

2. Assisting in the development of any project which will demonstrate advanced waste treatment and water purification methods (including the temporary use of new or improved chemical additives which provide substantial immediate improvement to existing treatment

processes) or new or improved methods of joint treatment systems for municipal and industrial wastes, and for the purpose of reports, plans and specifications in connection therewith.

Grants of up to a maximum of $1,000,000 or 70 percent of the project cost may be made to persons for research and demonstration projects for prevention of pollution of waters by industry including, but not limited to, treatment of industrial waste.

STATE GRANTS AND LOANS

An Act (Senate Bill 147) amending, revising and rearranging the Texas Water Quality Act of 1967 (Article 7621d-1, Vernon's Texas Civil Statutes) was passed in 1969. This Act authorized the Texas Water Quality Board to make grants or loans to municipalities, interstate agencies and local governments for the construction of sewer systems, treatment facilities and disposal systems. It also authorized the TWQB to make grants or interest-free loans to local governments, regional planning commissions and planning agencies for developing effective, comprehensive water quality control and pollution abatement plans.

Funds for the implementation of this program of grants and loans have not to date been appropriated. At such time as funds become available, the Act provides that the recipient of the grant or loan must agree to pay the difference between the amount of the grant or loan and the cost of the project, which difference must be at least 20 percent of the estimated project cost.

It is proposed in the Texas Water Plan that "A Clean Water " Fund be established to provide a program of State grants for sewerage systems as envisioned in the Federal Water Pollution Control Act as amended. The Plan further states, "This will not only stimulate action to abate and prevent pollution but also maximize the amount of Federal funds that may be obtained by Texas."

SUMMARY

At the present time the maximum financial assistance available from governmental sources for the construction of sewerage facilities in Texas is 33 percent of the project costs. If State assistance of at least 25 percent becomes available, the total grant for an eligible project may be as high as 80 percent. Such assistance will minimize the financial burden on taxpayers. Such assistance is expected to encourage construction of much needed sewerage facilities.

IMPLEMENTATION

The comprehensive regional sewerage system and its associated water quality management plan, as conceptually proposed in this report, is dependent upon the adoption of a feasible plan for implementation. The complexity and interaction of factors affecting water quality in such a large geographic area dictates the need for a high degree of regional coordination and cooperation.

Implementation arrangements and procedures must meet the following criteria at a minimum in order to stand the test of feasibility:

1. They must be suitable for effectively achieving the desired water quality standards;

2. They must be practical from the engineering/technical standpoint;

3. They must be economically sound in terms of efficiency;

4. They must be equitable.

5. They must maintain a consistent exposure to the public and a responsibility to the public interest.

6. They must assign clearly defined responsibility to existing or new agencies for all identified functions and actions required by the plan (planning, financing, acquisition, construction, operation, regulation, monitoring, etc.) for the entire geographic jurisdiction and all its components;

7. They must be compatible with and integrated with other regional plans and implementation procedures in functional areas such as public health, solid waste management, water supply, air quality control, transportation, recreation, land-use management, etc.;

8. They must recognize existing interests, responsibilities, and authorities and build upon available facilities and operational strengths;

9. They must define those actions requiring immediate and concurrent attention and assign responsibilities accordingly, describe and place responsibility for more intermediate type actions and objectives prescribed by the plan, and finally, assign responsibilites for achieving long-range objectives.

10. They must evaluate local interests and requirements which, due to economics and time considerations, require immediate planning and implementation, and will not detract from an overall regional concept.

This report has set forth a conceptual design and defined the requirements for achieving regional water quality management in the North Central Texas area. This implementation section recommends those immediate and concurrent steps needed to initiate the plan and suggests a procedure for accomplishing long-range objectives.

IMMEDIATE IMPLEMENTATION ACTIONS

To insure the needed coordination of immediate and concurrent activities by various organizations the following individual actions are suggested:

THE NORTH CENTRAL TEXAS COUNCIL OF GOVERNMENTS

1. Begin an education/information program to explain the proposed Plan to local, state and federal officials and to the general public.

2. Submit Proposed Plan to interested parties for their review and comment.

3. Revise the Proposed Plan as appropriate after consideration of the reviews.

4. Submit the Plan to the NCTCOG Executive Board.

5. Request that the Governor, state agencies, and federal agencies certify the plan as the official water pollution abatement plan in process of development for the study area.

6. Establish procedures for voluntary review and comment upon all plans for major new treatment facilities, collection and delivery systems, and appurtenances throughout the study area to determine consistency with the adopted Plan (NCTCOG already does this for facilities built with federal assistance).

7. Initiate an active program of encouragement to each operational agency in the region to meet the standards and criteria set forth in the Plan.

8. Actively encourage existing agencies to implement where possible any components of the Plan through interlocal contracts and agreements.

9. Designate existing facilities that become part of the system as a "North Central Texas Regional Sewerage System Facility" for better public visibility.

10. Request state and federal agencies to establish procedures to insure review by NCTCOG of proposed state and federal plans, regulations, standardsandorganizational arrangements with potential impact on the Plan and for consistency therewith.

11. Determine and suggest other actions by state or federal agencies which would help achieve Plan objectives.

12. Determine the nature and scope of personnel requirements indicated by the Plan and initiate the necessary training programs.

13. Continue and encourage specialized research in water quality management and share the results with local governments.

14. Review existing enforcement procedures available for achieving compliance, methods and responsibilities for monitoring water quality standards, and responsibility for initiating legal procedures against violators. Suggest areas needing improvement and formulate model ordinances for local adoption.

15. Maintain a program of water quality planning, to include continued updating of the Plan, and the immediate initiation of further studies as

needed to refine this implementation Plan.

16. Consult with existing agencies regarding their present plans for expansion, corrective actions, personnel needs, etc., to facilitate NCTCOG's coordinating and service roles.

LOCAL GOVERNMENTS, SPECIAL DISTRICTS, AUTHORITIES

1. Submit on a voluntary basis their sewerage facility expansion plans, plans for corrective actions, and other major proposed actions to NCTCOG for proper coordination with the Plan.

2. Exercise their full authority to implement the regulatory and operational standards suggested by the Plan throughout their jurisdictional area.

3. Undertake cooperative actions with neighboring jurisdictions which are consistent with the Plan.

4. Continue the determination of existing deficiencies and cooperate in establishing new arrangements for overcoming these deficiencies.

5. Coordinate with NCTCOG in regard to other functional planning and development activities which may influence local/regional water quality management.

6. Participate in the continuing process of water quality research and planning for the region.

7. Assist with further studies as needed by providing necessary local information.

8. Adopt recommended model ordinances for construction, operation and maintenance of sewerage systems.

STATE AND FEDERAL GOVERNMENT

1. Certify the approved Plan as the official water pollution abatement plan for the region.

2. Establish procedures for review by NCTCOG or some other appropriate jurisdiction of all federal/state actions, plans, regulations, standards or organizational arrangements with potential impact on the Plan.

3. Provide necessary legal authority, financial participation, and technical support for Plan implementation.

4. Coordinate with each other the effective and timely assistance requested by local agencies for initiating approved components of the Plan.

5. Consider grant assistance for further necessary studies.

PRIVATE ORGANIZATIONS

Private organizations, industries, developers and other groups or individuals undertaking projects which will effect the water quality in this region should inform themselves thoroughly as to the contents of this Plan. They should voluntarily seek the review and advice of NCTCOG or the appropriate agency or local government on their plans for projects. Every effort should be made to make these actions consistent with the criteria and objectives set forth in the Plan. Such cooperative responsibility will greatly reduce the necessary regulatory and compliance costs likely to result in the absence of this kind of pre-development planning.

PROPOSED ADDITIONAL STUDIES TO AID IN IMPLEMENTATION

In addition to the engineering analysis and conceptual design of a regional sewerage plan for the Upper Trinity River Basin, this report suggests in its conclusions and recommendations some general financial and organizational procedures that warrant consideration in plan implementation efforts.

Throughout a large percentage of the study area, it is proposed that the smaller more scattered communities, for economic reasons, stay by themselves and to provide their own individual water pollution control facilities.

In the metropolitan built-up areas surrounding Dallas and Fort Worth, however, six joint-use treatment facilities; namely, Fort Worth Village Creek, TRA Central, Richardson-Garland-Duck Creek, Dallas-White Rock, Dallas-South Side and TRA Ten Mile Creek are recommended to serve the area.

COST ALLOCATING STUDIES

It is recommended that several of the above six joint-use treatment facilities serve a considerable number of communities in addition to those which they now serve. It is suggested that studies be initiated to outline the various methods possible under which an equitable cost allocation can be affected.

PRELIMINARY ENGINEERING STUDIES

The scope of this report has, of necessity, been of a general nature. The next logical (and anticipated) step is to have preliminary engineering studies made of the six joint-use treatment facilities to refine:

1. The expansion size and timing.
2. The specific treatment process to be used.
3. The location of the units considering future additional expansions.
4. Land acquisitions necessary.
5. Cost (construction, operation and maintenance) and

6. The participating communities.

Preliminary engineering studies are a prerequisite to the preparation of construction plans and specifications and are required as a part of an application for construction grant assistance. Both Dallas and Fort Worth are already in the process of considering such studies.

POSSIBLE ORGANIZATIONAL ALTERNATIVES

Some of the possible organizational alternatives for regional sewerage system and water quality management implementation are:

1. A new single purpose (regional water quality) special district with jurisdictional responsibility for area-wide operation.

2. A multi-purpose single agency (e.g. a Master Regional Environmental Quality Authority) to administer related programs of solid waste disposal, water and air pollution, land use regulation, etc.

3. A single existing agency contractually serving all voluntary participants in a regional sewerage and water quality management system.

5. Joint ownership and operations region-wide with a multi-purpose regional agency to plan and coordinate activities for the entire geographic area, and with operational control in areas where no other jurisdiction is feasible.

6. Joint operations by largest existing operational agencies (such as Fort Worth, Dallas, TRA and NTMWD) contractually serving all other participants.

7. Several other multi-agency options, assigning functional responsibility for one or more functions such as financing, regulatory activities, or operations, to a region-wide agency.

This obviously is not an all inclusive listing of potential alternatives for organizational management. It is representative of the type of alternatives available.

CONCURRENT IMPLEMENTATION PROCEDURE

Water quality objectives in the area can be obtained only through the consistent and thorough administration of: wastewater collection, treatment and disposal facilities, installation, operation and maintenance of septic tank systems; solid waste disposal; and methods to measure and control pollution from surface runoff within the study area.

The six joint sewage treatment plants and collection systems recommended in this report are already in existence. The Fort Worth-Village Creek Plant serves by far the most communities (about seventeen at present). and Fort Worth is in the process of preparing a preliminary engineering report on the magnitude and timing of future

expansions to this plant to serve the watershed. The Trinity River Authority already operates the Central and Ten Mile Creek plants on a regional basis and has sufficient authority to continue to do so. The Dallas- White Rock and South Side Plants also serve more than one community at the present time, and Dallas is in the process of having preliminary engineering work done on expansion and also on the degree of wastewater treatment to be provided. The remaining recommended joint treatment plant, Richardson-Garland-Duck Creek, has just been the subject of a preliminary engineering study on expansion, although it did not cover as large an area as the watershed envisioned herein. These facts indicate that the metropolitan area is already well on its way toward effective, economical wastewater collection, treatment and disposal on an area-wide basis. The North Texas Municipal Water District which covers much of the East Fork Watershed has indicated its willingness to assume regional sewerage responsibilities in this area.

If the area communities do nothing more than follow the recommended plan contained in this report using, of course, good sound judgement in areas that cannot, as a practical matter, fully meet the recommended plan in the early years, this report will have fulfilled the purposes for which it was prepared.

NCTCOG now has the responsibility to serve as the Metropolitan Clearinghouse (metropolitan area-wide review). In this capacity NCTCOG coordinates, reviews and comments on applications from local governments and state agencies operating in the region and six adjacent "non-COG" counties for a broad range of Federal grants for such purposes as open space land, hospitals, airports, libraries, water supply and distribution, sewerage facilities and wastewater treatment, highways, other transportation facilities, water development and land conservation, law enforcement facilities, and planning. These review and comment functions give NCTCOG the means to see that the recommended plan is carried out under the present conditions.

Whether the joint treatment plants' expansion, operation and maintenance should be consolidated under one agency has been the subject of considerable discussion and comment during the preparation of this report. Savings could be realized in centralized operation and maintenance as discussed hereinafter. But acceptance and area-wide cooperation, essential to such action, is a necessary prerequisite.

It is suggested that meetings be held with representatives of the six joint areas to fully and frankly discuss the role that NCTCOG and the other agencies, districts, and cities may best play in the implementation of the recommended plan. TWQB has recently funded NCTCOG to develop such an implementation program, scheduled to be completed in March, 1971.

IMPLEMENTATION PROCESS: A SUMMARY

Concurrently with the initiation and progress of the above, a concerted educational effort must be initiated to promote the understanding and acceptance among both public and private sectors of the necessity of following a long-range regional plan for water quality management in the North Central Texas area. The economic and political implications of a project with the scope and cost of the conceptual engineering design proposed here must have a broad base of local support. An information and education program designed to accomplish this support throughout the region is considered essential.

A continuing process of consultation and mutual agreement at all levels of participation will be necessary to accomodate unexpected demographic and economic conditions, changes in available technology and other factors not readily foreseen at this early stage of planning. This type of consultation should consistently coincide with necessary new planning and not occur ex post facto. In each case, a range of feasible alternatives should be available for consultation and negotiation.

An essential process that must be accommodated within any adopted implementation plan and its subsequent modification is the region-wide multi-functional planning and coordination role. Water quality management cannot be accomplished in isolation from other functional areas such as transportation, public health, education, industrial development, and other equally important considerations.

As implied above, further study and planning processes are anticipated throughout the projected 50-year time horizon of this conceptual design. Responsibility for the coordination of these future efforts should be established now to insure orderly progress of implementation.

The recommended water quality management plan and conceptual engineering design, including this recommended strategy for implementation, are subject to review and approval by the two sponsoring agencies: Texas Water Quality Board and the Federal Water Quality Administration. Subsequent to this process, the plan will become the basis for future federal, state, regional and local actions, subject to local consultation, modification and adoption. The importance of developing an effective implementation program for the plan is indicated by the recent funding of NCTCOG by the TWQB for such a study.

ADMINISTRATIVE, OPERATION & MAINTENANCE PLAN

Effective centralized administration, operation and maintenance procedures for joint wastewater treatment plants, interceptors and pumping stations appear to be essential to the proper functioning of the system and the attainment of water quality objectives. A key feature of the plan discussed herein is that it makes continuous attendance at most pumping stations unnecessary by providing monitoring control of the pumping stations by leased wire telemetry with system-wide maintenance functions carried on from a centralized headquarters.

In the design stage, careful consideration should be given to the possibility of standardizing the principal equipment to permit interchangability of major parts to reduce spare parts inventory and to greatly simplify maintenance operating instruction. To provide the most economical efficient administration, operation and maintenance of the joint facilities an organizational structure is suggested as discussed below.

Administrative Headquarters. From the administrative headquarters (preferably at a central location for each watershed), facilities would be operated and monitored by leased line manned telemetry system, including automatic dialing telephones for individual unit control and signals. This would provide continuous pertinent selective operation information from all outlying facilities. Flow data, equipment in operation, elevations, level control, malfunctions, control of valves, power outages, and detection of entrance and egress of stations by unauthorized personnel would be continuously

monitored and results relayed back to the pertinent joint plant and to administrative headquarters. This automated system now used in similiar installations has many advantages over conventional manned stations. The number of operating personnel required to perform routine operational functions is reduced, allowing funds for these non-productive activities to be diverted to preventive and routine maintenance work. Each single manned 24-hour shift of five men eliminated represents \$50,000 per year minimum savings.

Laboratory. A principal laboratory would be located at a central location. All major and routine laboratory functions for the system could be conducted at this location. Sampling stations for collecting and running emergency tests when needed would be provided at other locations, but all routine control samples would be picked up at the plants, refrigerated and brought to the central laboratory where a highly skilled staff in a completely equipped laboratory would be maintained.

For those sewage plants in the North Central Texas area which do not have lab facilities the NCTCOG will offer a service of preparing the monthly lab reports to meet TWQB requirements. Mobile home parks and other private business may take advantage of the COG service for a reasonable fee.

Central Maintenance. All maintenance work in the joint system would be performed by and under the control of a maintenance and special services staff at the headquarters location. The justifications for this arrangement are numerous - it centralizes supervision, responsibility and control would be centralized, and the efficient use would be made of manpower and skills and assignment of craftsmen when they are most needed. Centralized maintenance would justify the installation and equipping of a complete machine shop which can accomplish on-site repairs to any piece of equipment used, assuring almost immediate return to service. The work load and specialities performed in such a central shop would include heat treating, metal spraying, fabrication, welding, burning, sandblasting, precision machine and mill work, and all usual inside and outside machinist activities. These combined functions will justify the payment of salaries adequate to attract and retain competent qualified employees.

Field Maintenance. To accomplish preventive routine and emergency maintenance work, use of special mobile repair units should be considered. These units are actually mobile machine shops equipped with crew compartments, hoses, light and heavy tools, grinders, welders, pumps, generators, blowers, and a working quantity of supplies. They would be dispatched from centralized locations to the various treatment plants and pumping stations with crews selected as required. These units, which are completely stocked with all necessary tools and parts, can accomplish necessary repairs or, if necessary, remove the entire unit for return to the central headquarters maintenance shop. The units would be in the sole charge of an operator who would be responsible for keeping them stocked, maintaining their emergency lighting units, pumps, and blowers, and is otherwise accountable for all expendable items.

Experience with similar units in other locations has been quite successful. The units may be purchased fully equipped at approximately \$25,000 at the present time with accommodations for a five-man crew, and including a mobile radio. For convenience and to reduce travel time, a unit could be stationed at a work site for as long a period of time as needed while work is in progress.

Stockroom and Supply Depot. A centralized headquarters stockroom under audit control would result in efficient handling of all supplies, tools, inventory, and requisitioning. Disbursement would be made to authorized personnel on signature, with purpose and location of use stated.

Training. A continuous in-service training program as presently conducted by the NCTCOG RegionalTraining Center is of great value in up-grading the number and skills of plant operating personnel. Water pollution control is a very specialized field, and experience indicates proper care and maintenance of those facilities can be accomplished most economically by properly-trained permanent career employees. Training opportunities also provide the incentive for employees to advance and remain with the organization. We recommend present courses offered by the North Central Texas Council of Governments be continued with special emphasis given to subjects on maintenance of mechanical equipment, metal spraying, communications, telemetry, electronics, laboratory procedures, and operation functions.

Organization. Proposed organization to execute these recommendations in general would consist of professional staff, each individual having system-wide responsibilities including operation, management, legal, laboratory, sanitary, mechanical, electrical, and maintenance functions.

Personnel assigned for operational activities would be separated entirely from maintenance personnel and maintenance activities. It is considered that personnel now assigned to facilities for which phasing out or consolidation is proposed, would be utilized insofar as possible at the proposed joint facilities.

CHAPTER XIII

FINANCIAL PROGRAM

DISCUSSION

A financing plan is essential for the implementation of the regional sewerage plan recommended herein. Financial assistance available from Federal and State sources, as well as general plan implementation procedures, is discussed in Chapter XII. Inasmuch as all cost estimates presented in this report are based upon generalized cost data and no field surveys have been conducted, financial information presented in this chapter should be considered approximate only. Firm estimates of project costs, unit costs per household, etc., must await more detailed studies.

It is recognized that the municipal bond market is now in a state of flux. The discussion presented below is given in terms of a 30-year bond period at an interest rate of 6-1/2 percent. To determine specific rates and periods for bonds, whether of the revenue or general obligation type, one must await analysis of the market at the time the project is financed. A number of potential methods for calculating financing charges are available as discussed below.

COMPARATIVE METHODS OF FINANCING

Three potential methods of calculating bond repayment charges are discussed below. These three methods are referred to as:

1. Equal principal, decreasing interest.
2. Installments increasing with time.
3. Equal installments.

In the study area, it is anticipated that 2,562,000 people will be served by the joint systems in the first full year of financing the Initial construction program (1975), and that 4,587,000 people will be served in the fifteenth year (1990), reflecting an annual population growth rate of about four percent. For these cost analyses, an average household is considered to consist of 3.5 persons. Therefore, it is anticipated that approximately 731,800 and 1,310,000 households will be served by joint systems in 1975 and 1990 respectively. The estimated cost for the Initial Stage Construction program is $268,680,000 including land costs. The estimated cost of the Future Stage 1 construction program has not been considered in discussing the comparative methods of financing.

EQUAL PRINCIPAL, DECREASING INTEREST

Under this method, for each dollar borrowed, an equal amount of principal ($0.0333) would be repaid each year, together with interest due on principal still outstanding. In the first year the interest due would be $0.0650, and it would decrease linearly with time to zero at the end of 30 years. The average interest payment on each dollar borrowed would be $0.0325, and the average installment, therefore, would be $0.0658

($0.0325 + $0.0333). The estimated cost per household would be $36.10 in 1975 and $13.50 in 1990, not including operation and maintenance costs. This system has been assumed in the annual costs presented in Chapters IX and X.

INSTALLMENTS INCREASING WITH TIME

This method of repayment is considered as a possibility in order to balance repayment charges with population growth. It is recognized that the equal principal, decreasing interest method places a great financial burden on persons residing in a service area in early years. The rapid population growth anticipated in the study area makes attractive this method which also calls for installments increasing with time.

Installments may be scheduled to increase annually at a rate equal to the rate of projected population growth, so that the per capita payment remains approximately constant over the 30-year period. If installments are to increase 4 percent annually to keep pace with the population growth, the first annual installment would be $0.0486, and the 30th annual installment would be $0.1515, for each dollar borrowed. The average annual installment would be $0.0981 for each dollar borrowed. The estimated cost per household for the initial stage construction program, not including operation and maintenance costs, would remain at a constant value of $17.90 for all years through 1990. We suggest that this potential method of repayment be given consideration by finance specialists.

EQUAL INSTALLMENTS

This method is used in computing mortgage payments and results in increasing principal and decreasing interest payments with time. For each dollar borrowed, an equal annual installment of $0.0765 would be paid. The estimated cost per household for the Initial Stage construction program, not including operation and maintenance, would be $28.10 in 1975, decreasing to $15.70 in 1990. Average household costs using this method may be seen to represent a compromise between the other two comparative methods of bond repayment.

When considering financing methods, it should be kept in mind that not only the Initial Stage, but also Future Stage 1 and Future Stage 2, must be financed in due course. Costs for each stage may overlap those incurred for the other stages during certain periods of time depending on repayment periods and dates when actual debts are incurred.

OUTSTANDING DEBT ON EXISTING PLANTS

To cities having existing sewage treatment plants and major trunk sewers on which debts remain to be repaid, it is important to consider what dispostion if any may be made of these debts. No recognition of these outstanding debts has been taken in the cost estimates and financing tables presented in this report. However, as indicated in Chapter XII, it is considered reasonable that a joint-use sewer agency would acquire existing facilities to be phased out or to be utilized as part of the joint system.

If a joint-use sewer agency were to acquire the outstanding debts of existing treatment plants, it would be essential to know in advance the amount of the outstanding debt on each facility. Such information has been obtained for most of the treatment plants

affected by the joint system recommendations made herein. Table XIII-1 presents data on the outstanding debt on sewage treatment plants to be phased out under the recommended regional plan, and Table XIII-2 in addition, presents outstanding debt information on sewage treatment plants which are to be designated as joint plants under the recommended regional plan. It is estimated that there is at present a total outstanding debt on treatment plants in the joint systems area of about 25 million dollars based on available data. Of this figure approximately five million dollars may be attributed to the 46 plants which would be phased out before the year 2020, and the remainder is attributed to the outstanding debts on the six joint treatment plants.

FINANCING THE INITIAL CONSTRUCTION PROGRAM

Financing costs attributable to the initial construction program only have been developed for each of the six joint systems proposed as part of the recommended regional sewerage plan. These costs have been developed on the one hand considering no State or Federal assistance. The costs have been presented on the basis of estimated costs per household per year for the first full year of operation (1975) and also for the average year during the 1975 to 1990 period.

The costs of joint systems (including construction, operation and maintenance) in each of the six watersheds are presented in Tables XIII-3 to XIII-8. Similar costs for the entire initial construction program for all joint systems are presented in Table XIII-9, and comparative costs per household for all joint systems constructed as part of the initial construction program are presented in Table XIII-10.

In all of the various tables, it is important to note that per-household costs would tend to decrease with time as more people are connected to the joint systems, on the basis of the bond repayment method assumed (equal principal, decreasing interest). This tendency is affected only in degree by the actual rates of growth of the sewered population.

No allowances have been made in the costs presented for the collection and treatment of industrial wastewaters at joint treatment plants. Such wastewaters would have the effect of reducing somewhat the costs per residential household. Neither have any allowances been made for the possibility of instituting regional or joint-use area assessments. These allowances would also tend to reduce average household costs. Thus, the costs shown in the tables are considered to be on the high side.

As discussed in Chapter XII, more detailed preliminary engineering studies and an analysis of cost allocation methods between communities is desirable prior to the implementation of the systems proposed herein.

PAYMENT METHODS

There are many methods of paying for a comprehensive sewerage plan such as that proposed herein. Although NCTCOG would probably not be involved in decisions as to how individual communities would pay for the required works, a brief description of some of the more common methods is presented below. Payment methods discussed herein concern both construction costs and operation and maintenance costs.

TABLE XIII-1. OUTSTANDING DEBT ON SEWAGE TREATMENT PLANTS TO BE PHASED OUT UNDER PROPOSED REGIONAL SYSTEM

Node No.	Name or Location	Outstanding Unpaid Balance
TRINITY RIVER - WATERSHED 1		
1D-145	Wilmer	$61,000*
IE-147	Kleberg	105,000
1E-149	Balch Springs (Dallas-Hickory Tree WCID #6)	840,000*
1E-150	Seagoville Federal Correctional Institute	0
1G-143	Hutchins	-
1H-66	Richardson-Floyd Branch	-
EAST FORK TRINITY - WATERSHED 3		
3A-58	Seagoville	126,000
3B-16	Rockwall	134,000
3C-54	Mesquite	1,133,000
3E-26	Plano	0
3E-40	Garland-Rowlett Creek	0
3G-34	Wylie	-
3H-3	McKinney - North	0
3H-24	McKinney - South	0
ELM FORK TRINITY - WATERSHED 4		
4A-81	Lewisville	410,000*
4B-156	Grapevine	-
4B-170	Green Acres Estates	-
WEST FORK TRINITY - WATERSHED 5		
5A-20	Keller (N. Tarrant Co. M.W.D.)	234,000
5A-24	Grapevine	-
5A-60	Greenview Addition	-
5B-170	Green Valley Mobile Home Park	-
5E-195	Arlington	-
5F-184,188	Euless (West and East)	269,192
5F-189	Greater Southwest Airport	-
5G-130	Burleson	323,000
5G-132	Crowley	160,000
5G-133	Sunny Acres Mobile Home Park (Crowley)	-
5G-136	Everman	3,000
5G-137	Kennedale	-
5G-138	Forest Hill	-
5H-141	Banfield Mobile Home Park	20,000
5H-143	Royal Coach Mobile Home Park	60,000
5H-145	L & M Mobile Home Park	6,000
5H-149	Treetop Mobile Home Park	0

TABLE XIII-1. OUTSTANDING DEBT ON SEWAGE TREATMENT PLANTS TO BE PHASED OUT UNDER PROPOSED REGIONAL SYSTEM (Continued)

Node No.	Name or Location	Outstanding Unpaid Balance
WEST FORK TRINITY - WATERSHED 5 (Continued)		
5H-150	Treetop (South) Mobile Home Park	-
5H-153	Tumbleweed Mobile Homes	0
5H-156	Wilson Mobile Homes	$6,000
5H-157	Parsons	6,000
5H-159	Poly-Webb Mobile Home Park	-
5J-17	Keller Mobile Home Park	-
5J-107	Haltom City	-
5J-112	Richland Hills (TCWSC #2)	-
5M-101	Fort Worth - Riverside	583,320
5M-172	TCWSC #1 (Highway 820)	-
5Q-71	Benbrook	141,000
5S-59	Lakeside	-
5S-175	Azle (TCWSC)	-
	Total	$4,817,000

*Denotes no differentiation between sewerage portion and STP.

TABLE XIII-2. OUTSTANDING DEBT ON SEWAGE TREATMENT PLANTS TO BECOME JOINT PLANTS UNDER PROPOSED REGIONAL SYSTEM

Node No.	Name or Location	Outstanding Unpaid Balance	
1I-175	Dallas - White Rock	$5,357,000	
1F-146	Dallas - South Side	854,000	
1D-161	Ten Mile Creek	2,363,000	
3D-23	Duck Creek	500,000	(Est.)
4A-166	TRA Central	2,760,000	
5G-180	Village Creek	7,608,000	
	Total, Joint Plants	$19,442,000	
	Total, Plants to be Phased Out	4,817,000	
	Grand Total	$24,259,000	

TABLE XIII-3. LOCAL COSTS FOR INITIAL CONSTRUCTION PROGRAM

DALLAS - WHITE ROCK JOINT SYSTEM - WATERSHED 1

LOCAL COSTS WITHOUT AID

	First Year 1975	Average 1975-1990
Estimated Construction Cost		$44,630,000
Amortized Annual Cost (6 1/2% over 30 years)	$4,380,000	$2,940,000
Annual Operation and Maintenance Costs	5,740,000	6,980,000
Total	$10,120,000	$9,920,000
Estimated Number of Households	250,900	285,900
Estimated Cost per Household	$40.40	$34.80

LOCAL COSTS WITH 80% STATE AND FEDERAL AID

	First Year 1975	Average 1975-1990
Estimated Construction Cost		$8,920,000
Amortized Annual Cost (6 1/2% over 30 years)	$880,000	$590,000
Annual Operation and Maintenance Costs	5,740,000	6,980,000
Total	$6,620,000	$7,570,000
Estimated Annual Cost per Household	$26.40	$26.50

Note: Land costs are included.

TABLE XIII-4. LOCAL COSTS FOR INITIAL CONSTRUCTION PROGRAM

DALLAS - SOUTH SIDE JOINT SYSTEM - WATERSHED 1

LOCAL COSTS WITHOUT AID

	First Year 1975	Average 1975-1990
Estimated Construction Cost		$23,150,000
Amortized Annual Cost (6 1/2% over 30 years)	$2,270,000	$1,520,000
Annual Operation and Maintenance Costs	1,900,000	2,430,000
Total	$4,170,000	$3,950,000
Estimated Number of Households	68,000	83,700
Estimated Cost per Household	$61.40	$47.20

LOCAL COSTS WITH 80% STATE AND FEDERAL AID

	First Year 1975	Average 1975-1990
Estimated Construction Cost		$4,630,000
Amortized Annual Cost (6 1/2% over 30 years)	$450,000	$300,000
Annual Operation and Maintenance Costs	1,900,000	2,430,000
Total	$2,350,000	$2,730,000
Estimated Annual Cost per Household	$34.50	$32.60

Note: Land costs are included.

TABLE XIII-5. LOCAL COSTS FOR INITIAL CONSTRUCTION PROGRAM

TRA TEN MILE CREEK JOINT SYSTEM - WATERSHED 1

LOCAL COSTS WITHOUT AID

	First Year 1975	Average 1975-1990
Estimated Construction Cost		-
Amortized Annual Cost (6 1/2% over 30 years)	-	-
Annual Operation and Maintenance Costs	$200,000	$970,000
Total	$200,000	$970,000
Estimated Number of Households	16,800	27,400
Estimated Cost per Household	$11.90	$35.40

LOCAL COSTS WITH 80% STATE AND FEDERAL AID

	First Year 1975	Average 1975-1990
Estimated Construction Cost		-
Amortized Annual Cost (6 1/2% over 30 years)	-	-
Annual Operation and Maintenance Costs	$200,000	$970,000
Total	$200,000	$970,000
Estimated Annual Cost per Household	$11.90	$35.40

Note: Land costs are included.

TABLE XIII-6. LOCAL COSTS FOR INITIAL CONSTRUCTION PROGRAM

DUCK CREEK JOINT SYSTEM

LOCAL COSTS WITHOUT AID

Estimated Construction Cost		$74,600,000
	First Year 1975	Average 1975-1990
Amortized Annual Cost (6 1/2% over 30 years)	$7,340,000	$4,920,000
Annual Operation and Maintenance Costs	2,280,000	4,270,000
Total	$9,620,000	$9,190,000
Estimated Number of Households	78,300	149,700
Estimated Cost per Household	$123.00	$61.40

LOCAL COSTS WITH 80% STATE AND FEDERAL AID

Estimated Construction Cost		$14,920,000
	First Year 1975	Average 1975-1990
Amortized Annual Cost (6 1/2% over 30 years)	$1,470,000	$980,000
Annual Operation and Maintenance Costs	2,280,000	4,270,000
Total	$3,750,000	$5,250,000
Estimated Annual Cost per Household	$47.90	$35.00

Note: Land costs are included.

TABLE XIII-7. LOCAL COSTS FOR INITIAL CONSTRUCTION PROGRAM

TRA CENTRAL JOINT SYSTEM

LOCAL COSTS WITHOUT AID

Estimated Construction Cost		$63,390,000
	First Year 1975	Average 1975-1990
Amortized Annual Cost (6 1/2% over 30 years)	$6,230,000	$4,160,000
Annual Operation and Maintenance Costs	2,810,000	4,910,000
Total	$9,040,000	$9,070,000
Estimated Number of Households	107,200	182,800
Estimated Cost per Household	$84.20	$49.60

LOCAL COSTS WITH 80% STATE AND FEDERAL AID

Estimated Construction Cost		$12,680,000
	First Year 1975	Average 1975-1990
Amortized Annual Cost (6 1/2% over 30 years)	$1,250,000	$830,000
Annual Operation and Maintenance Costs	2,810,000	4,910,000
Total	$4,060,000	$5,740,000
Estimated Annual Cost per Household	$37.80	$31.40

Note: Land costs are included.

TABLE XIII-8. LOCAL COSTS FOR INITIAL CONSTRUCTION PROGRAM

VILLAGE CREEK JOINT SYSTEM

LOCAL COSTS WITHOUT AID

Estimated Construction Cost			$62,910,000
		First Year 1975	Average 1975-1990
Amortized Annual Cost (6 1/2% over 30 years)		$6,180,000	$4,140,000
Annual Operation and Maintenance Costs		4,950,000	7,170,000
	Total	$11,130,000	$11,310,000
Estimated Number of Households		210,600	291,600
Estimated Cost per Household		$52.80	$38.90

LOCAL COSTS WITH 80% STATE AND FEDERAL AID

Estimated Construction Cost			$12,580,000
		First Year 1975	Average 1975-1990
Amortized Annual Cost (6 1/2% over 30 years)		$1,240,000	$830,000
Annual Operation and Maintenance Costs		4,950,000	7,170,000
	Total	$6,190,000	$8,000,000
Estimated Annual Cost per Household		$29.40	$27.50

Note: Land costs are included.

TABLE XIII-9. LOCAL COSTS FOR INITIAL CONSTRUCTION PROGRAM

ALL JOINT SYSTEMS

LOCAL COSTS WITHOUT AID

Estimated Construction Cost		$268,680,000
	First Year 1975	Average 1975-1990
Amortized Annual Cost (6 1/2% over 30 years)	$26,400,000	$17,700,000
Annual Operation and Maintenance Costs	18,260,000	26,730,000
Total	$44,660,000	$44,430,000
Estimated Number of Households	731,800	1,021,100
Estimated Cost per Household	$61.00	$43.40

LOCAL COSTS WITH 80% STATE AND FEDERAL AID

Estimated Construction Cost		$53,740,000
	First Year 1975	Average 1975-1990
Amortized Annual Cost (6 1/2% over 30 years)	$5,290,000	$3,540,000
Annual Operation and Maintenance Costs	18,260,000	26,730,000
Total	$23,550,000	$30,270,000
Estimated Annual Cost per Household	$31.80	$29.60

Note: Land costs are included.

TABLE XIII-10. COMPARATIVE ANNUAL COSTS PER HOUSEHOLD FOR ALL WATERSHEDS FOR INITIAL CONSTRUCTION PROGRAM

	COSTS WITHOUT AID		COSTS WITH 80% STATE AND FEDERAL AID	
	First Year 1975	Average 1975-1990	First Year 1975	Average 1975-1990
WATERSHED 1				
Dallas - White Rock Plant	$40.40	$34.80	$26.40	$26.50
Dallas - South Side Plant	61.40	47.20	34.50	32.60
Ten Mile Creek Plant	11.90	35.40	11.90	35.40
WATERSHED 3				
Duck Creek Plant	123.00	61.40	47.90	35.00
WATERSHEDS 4, 5				
TRA Central Plant	84.20	49.60	37.80	31.40
WATERSHED 5				
Village Creek Plant	52.80	38.90	29.40	27.50
Annual cost per household if shared equally by all households served by joint systems	$61.00	$43.40	$31.80	$29.60

Note:

Costs do not include outstanding debt on existing facilities to be phased out under proposed system.

Sewerage systems provide both public and private benefits. Public benefits include improved public health, recreation and aesthetic values, and general economic development in the community. Private benefits include elimination of septic tank system costs and nuisances and increased property values. Each parcel of land, occupied or unoccupied, connected or not connected to the sewerage system, may be considered to benefit directly or indirectly from the sewerage system. Each person in a community benefits from the installation of a sewerage system although obviously the user benefits more directly than the non-user.

PAYMENT FOR CONSTRUCTION

Ad valorem Tax. Inasmuch as the sewage treatment plant and major pumping stations and interceptors are proposed to be designed with capacity for future development and population in the tributary area, it is common practice to consider that the cost of these facilities be paid through the general property or ad valorem tax. Since everybody benefits directly or indirectly from such facilities, everyone pays. The general property or ad valorem tax does not provide total equity, of course, because it is based on property valuation.

Sewer Service Charge. Some communities in the region now pay for all construction (capital costs), as well as operation and maintenance, as part of their yearly sewer service charges. Although there is nothing wrong with this method, it does place the entire burden of paying for future capacity on the people presently using the system.

Street Sewers. Individual street (lateral) sewers which serve small areas can, of course, be paid for as part of the general property or ad valorem tax. They can also be financed by the people served on a front foot, or land area betterment assessment bases. It is usually difficult (as a practical matter) to change the method of sewer system financing once a community has adopted a method and sewer construction is underway. This is because inequities will be created on what has already been paid for.

Building or house connections should be extended to the street-property line when the street sewer is installed to eliminate the need in the future to again dig up the street. The house connection cost in many areas is paid for by the property owner because it is considered a private benefit facility.

PAYMENT FOR OPERATION AND MAINTENANCE

Most communities pay for operation and maintenance of sewerage systems through service charges to users. In some cases, these charges make up the entire cost, while in others, user charges are supplemented by funds from general property taxes. The three methods most commonly used in computing user charges are the flat rate, unit rate and water usage methods. Those institutions exempt from general property-ad valorem taxes are able to be assessed service charges.

Flat Rate Method. The flat rate method is a simple method in which the cost of operating this system is divided equally among all users.

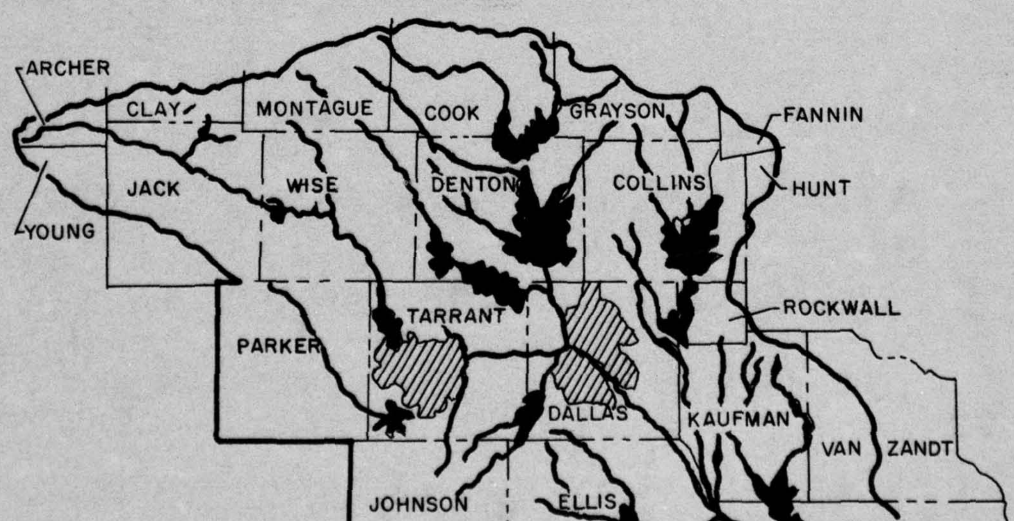
Unit Rate Method. This method requires an agreement as to the unit to be used as the basis for charge. The unit could be the pipe size, number of fixtures, or type of building configuration. For example, dwellings might be classified as to type and each user would pay according to the type of building he occupied.

Water Usage Method. This method is based on metered water consumption. It is considered to be reasonable inasmuch as sewage flow is directly related to water consumption, as discussed in Chapter V. The principal difficulty with the water usage method is that some users in communities do not have metered water, and in such cases, the unit or flat rate method might be necessary. In addition to charges based on water usage, many communities impose surcharges for treatment of industrial and commercial wastes when they are stronger than normal domestic sewage.

SUMMARY

A number of methods are available for paying the construction, operation and maintenance costs for the facilities proposed herein. No single method is recommended, and combinations of several methods may be acceptable in a given community, but it is generally accepted that for the construction of major facilities such as those proposed herein, the property tax or ad valorem tax is considered to be the most equitable. For operation and maintenance costs, the service charge (water usage method) is generally considered to be the most equitable, particularly where such usage is metered.

UPPER TRINITY RIVER BASIN
COMPREHENSIVE SEWERAGE PLAN



**north central texas
council of governments**

north central texas council of governments

UPPER TRINITY RIVER BASIN COMPREHENSIVE SEWERAGE PLAN

September, 1970

Consultant Team

Camp, Dresser & McKee
Forrest and Cotton Inc.
Freese, Nichols and Endress

Funded by Texas Water Quality Board
and Federal Water Quality Administration

OBJECTIVE OF THE STUDY

The objective of this study is to prepare a plan which will recommend an area-wide comprehensive sewerage system and program for interceptor and trunk sewers and sewage treatment and disposal facilities in the North Central Texas region and to suggest methods for plan implementation. The output from this study is expected to be of great value not only to the North Central Texas Council of Governments (NCTCOG) but to all member communities in their planning for future development of the area.

Specific watershed recommendations presented in this report are not considered to be absolute because of the generalized nature of the studies. The recommendations are, however, meant to be utilized as a basis of comparison with other possible alternative systems on a watershed basis. Detailed studies for specific localities and projects may indicate that size, location and staging of facilities should depart from the recommendations herein.

CONSULTANT TEAM

In January 1969, the North Central Texas Council of Governments contracted with the consulting engineering firm of Camp, Dresser & McKee of Boston, Massachusetts, to direct and coordinate the work of the consulting team. The consultant team consists of Camp, Dresser & McKee, as the general consultants, and the firms of Forrest and Cotton, Inc. of Dallas, and Freese, Nichols and Endress of Fort Worth as associate consultants. Other special consultants (including legal) were utilized where needed during the preparation of the report.

FINANCING OF STUDY

This report was financed jointly by the Texas Water Quality Board under Contract No. TWQB PG68-1 and the Federal Water Quality Administration (formerly the Federal Water Pollution Control Administration), U.S. Department of the Interior, Project BPG-3-68-12.

AREA OF STUDY

The study encompasses an area of roughly 11,000 square miles located in the North Central part of Texas, including the entire counties of Dallas, Tarrant, Ellis, Denton, Johnson, Collin, Kaufman, Parker, Rockwall and Wise, and those portions of Van Zandt, Henderson, Fannin, Hunt, Grayson, Cooke, Montague, Clay, Jack, Archer and Young tributary to the Upper Trinity River Basin. This area is much larger than several states including Rhode Island and Massachusetts, more populous than Arkansas, Colorado, Nebraska, Oregon and eighteen other states, and includes the metropolitan area of Dallas and Fort Worth. The area contains about 20% of the population of the State of Texas.

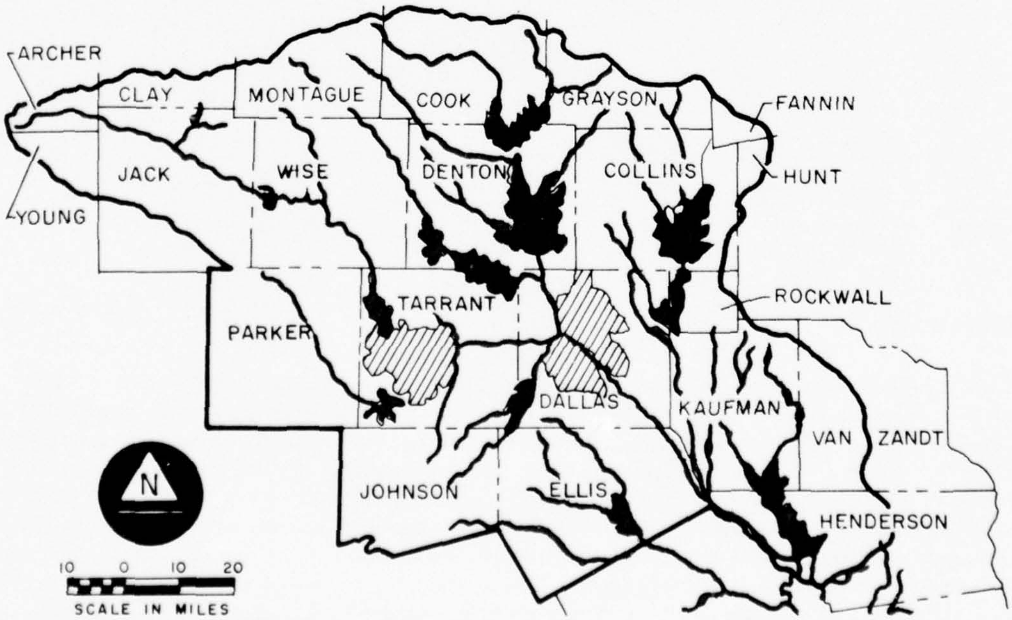


Fig. I-1 Map of Study Area

POPULATION

The population in the study area at the present time is estimated at about 2.7 million, and is expected to almost double in the next twenty years. By the year 2020 the population is expected to reach 7.8 million. Over 80% of the present population is already sewered, and it is expected that this percentage will climb in the next fifty years to about 97% by the year 2020. The area is blessed with sufficient land and sufficient water (at least for the next twenty years or so) to attract and hold new industry and to permit rapid developments and population growth. Beyond 1990 it appears that additional water supplies (from imported or reused water)may be needed to sustain growth. It appears that most of the population (present and future) will reside in the metropolitan areas surrounding Dallas and Fort Worth, and generally lying within Dallas and Tarrant Counties.

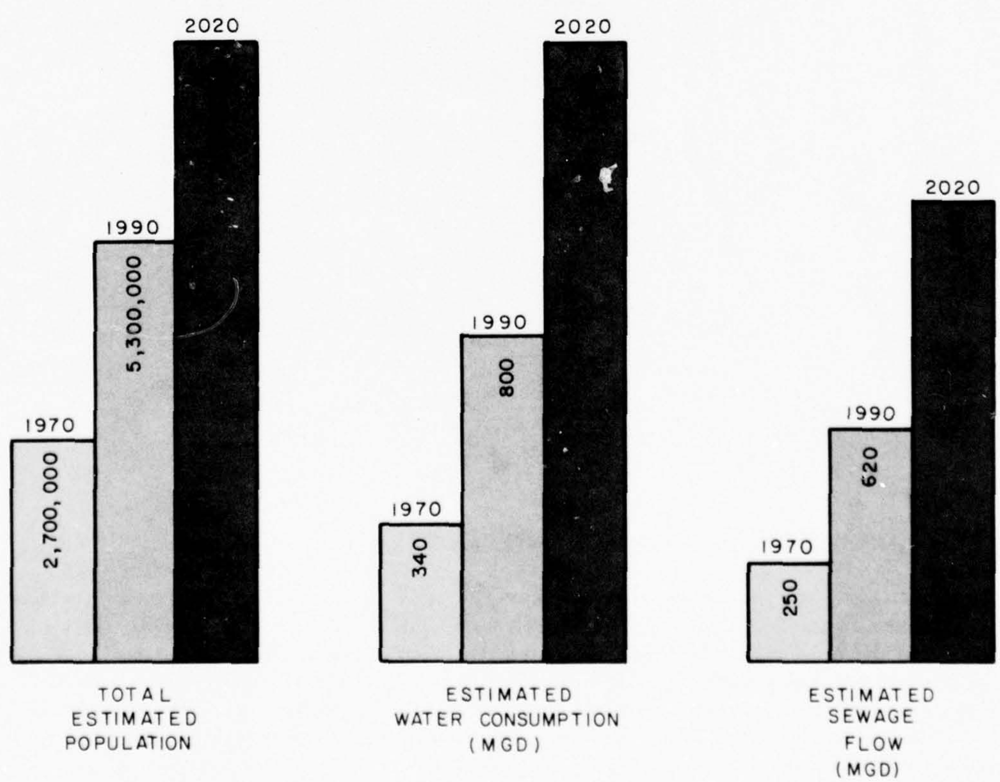


Fig. I-2 Projected Population, Water Consumption and Sewage Flow for Study Area

WATER CONSUMPTION AND SEWAGE FLOW

Accompanying this increase in population will be a great increase in water consumption and sewage flow in the study area. Total water consumption is expected to increase from an estimated 340 million gallons per day at the present time to about 1,510 million gallons per day by the year 2020. Most of the water consumed will find its way into municipal sewerage systems and require treatment. From an estimated 250 million gallons a day at the present time, the projected sewage flow to the year 2020 is expected to increase to about 1,140 mgd. On a per capita basis average daily sewage flow is expected to increase from 100 gpcd in 1970 to 150 gpcd in 2020 in the Dallas-Fort Worth metropolitan area.

UPPER TRINITY RIVER WATER QUALITY

Flowing generally from the northwest to the southeast through the North Central Texas region is the Trinity River and its principal tributaries, the West Fork, Elm Fork and East Fork. The flow in the Trinity River is extremely variable - from flood waters in the early spring to almost no natural flow in the dry parts of the year. This extreme variation in flow presents difficulties in attempts to use the Trinity River for recreational and other purposes, and it affects the degree of sewage treatment necessary. Several large water supply reservoirs are located in the basin and their discharges flow into the Trinity River during wet parts of the year. The Trinity River itself flows downstream into the site of the planned (by others) Tennessee Colony Reservoir located at the southern edge of the study area. This reservoir is a projected water supply for a portion of Texas south of our study area. Some reservoirs within the study area receive sewage effluents.

In the dry parts of the year, the flow in the Upper Trinity River and its tributaries consists mostly of the effluent (or discharge) from existing sewage treatment plants, and dissolved oxygen levels are frequently below those necessary to maintain fish life. During the summer months reported biochemical oxygen demand (BOD) and dissolved oxygen levels in many reaches of the Upper Trinity River do not meet the water quality requirements of the TWQB. Extremely high concentrations of nutrients such as phosphates and nitrates are found in the river, and bacteria counts are frequently above acceptable levels particularly during wet weather periods. Reported pesticide concentrations, where they exist at all, are below established limits.

The heavy pollution load in the river results from the discharge of effluents from 132 sewage treatment plants, septic tank discharges, raw sewage discharges from homes, industrial wastewater discharges, leaching from refuse disposal dumps and sanitary landfills, and surface runoff from urban and rural areas. During high river levels, treatment plant sludge lagoons are occasionally flooded and quantities of sludge are carried away by the river.

Thus the Upper Trinity River now poses a potential health hazard, does not satisfy aesthetic considerations and is not suitable for many desired uses.

However, streams and lakes in the Upper Trinity River basin are used at the present time for water supply purposes. In order to protect the public health, to prevent eutrophication (the accelerated aging or deterioration) of lakes and reservoirs and to permit various desired river uses, the sewage from the North Central Texas region must be provided with a very high degree of organic removal combined with nutrient removal and disinfection.

The planned canalization of the Trinity River contains a number of locks and dams, which will tend to retard the natural flow of water. The same very high degree of treatment (advanced treatment) of the area's sewage would be necessary to prevent eutrophication and other undesirable conditions from developing in the river because of this project.

It is considered not feasible to augment the flow of the Upper Trinity River to provide a great flow of water for dilution purposes during low flow periods. An amount of clean augmentation water roughly equivalent to twice the sewage flow from the entire study area (i.e., 1,240 mgd in 1990; 2,280 mgd in 2020) would be required if conventional secondary treatment only were provided. The time of year during which this water would be needed does not coincide with the timing of available water or that which could be made available (except through importation).

DESCRIPTION OF PROPOSED JOINT FACILITIES

For reasons of economics, centralization of responsibility, and administration of construction, operation and maintenance, six large joint use treatment plants are proposed for sewage treatment in the metropolitan area of Dallas and Fort Worth. Each of these plants exists or is under construction at present. A map of the metropolitan area and the location of the six joint treatment facilities is shown below. A list of the communities and service areas served or proposed to be served by each is as follows (those communities and service areas whose names are preceded by an asterisk (*) are not yet served by the indicated plants):

TRA CENTRAL

Arlington (part)
Carrollton
Colleyville (part)
Dallas (part)
East Mountain Creek area (part)
Euless
Farmers Branch
Grand Prarie
Grapevine Creek area
Greenview area
Hackberry Creek area
Irving
Kirby Creek area

*Bedford
*Colleyville (part)
*Coppell
*Grapevine
*Hurst (part)
*Keller
*Lewisville
*North Richland Hills (part)
*Regional Airport
*Southlake
*Future development north and west of the proposed Lakeview Reservoir

TRA TEN MILE CREEK PLANT

Cedar Hill
Ferris
Lancaster

De Soto
Woodland Hills
Duncanville

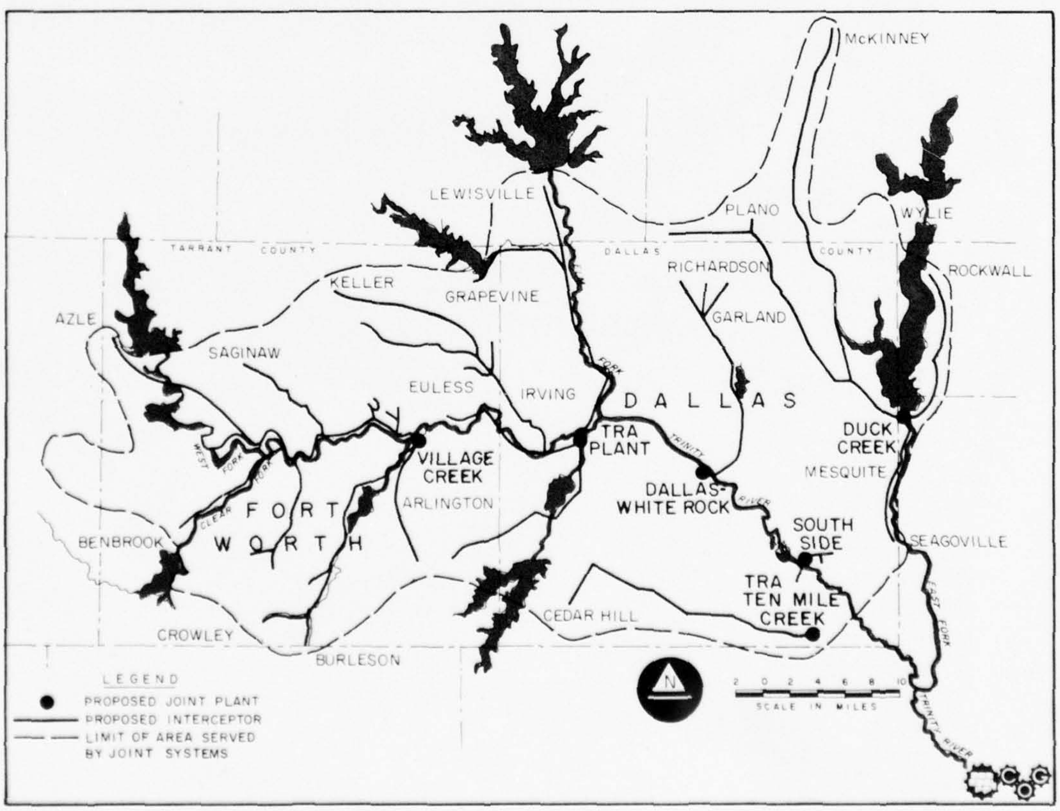


Fig. I-3 Recommended Regional Sewerage Systems

DALLAS WHITE ROCK PLANT

Dallas (area near the plant and Coombs Creek, Fair Park and White Rock Creek)

*Richardson (Floyd Branch and Cottonwood Creek)

DALLAS SOUTH SIDE PLANT

Elam Creek area
Five Mile Creek area
Prarie Creek area

*Balch Springs
*Hutchins
*Kleberg
*Wilmer

GARLAND-DUCK CREEK PLANT

Garland (part)
Mesquite (part)
Plano (part)
Richardson (part)
Sunnyvale (part)
*Allen
*Garland (part)
*Heath
*Long Creek Area
*McKinney

*Mesquite (part)
*North Mesquite Creek area
*North Seagoville
*Plano (part)
*Richardson (part)
*Rockwall
*Rowlett
*Sachse
*Seagoville (incl Fed. Corr. Instit.)
*Wylie

FORT WORTH VILLAGE CREEK PLANT

Benbrook
Blue Mound
Edgecliff
Everman
Forest Hill
Fort Worth
Haltom City
Hurst (part)
Kennedale
Lake Worth
North Richland Hills (part)
Richland Hills (part)
River Oaks
Saginaw
Sansom Park
Watauga
White Settlement
Arlington (part)
*Azle
*Crowley
*Everman
*Lakeside
*Richland Hills (part)
*Rush Creek Area

ESTIMATED CONSTRUCTION, OPERATION AND MAINTENANCE COSTS

The expected population and the average sewage flow to the six joint treatment facilities, the estimated construction costs (1970 construction costs) estimated to be needed between now and the year 1990, and the estimated annual average operation and maintenance costs connected with these new facilities between now and the year 1990 are shown on Fig. I-4 and Fig. I-5.

Based on 1970 cost estimates, the people living in the metropolitan area, which may be served by these six joint treatment facilities, can expect to have the cost associated with intercepting sewers and sewage treatment increase about three times over the present cost. A portion of this cost (the construction portion) would, of course, be reduced by the amount of grants in aid available from the Federal and/or State Governments. On an average household basis using 1970 cost estimates, the average annual cost for the recommended joint treatment systems including sewage treatment plants and new interceptor sewers is estimated at about $60 per year, or less than 20¢ per day per family. On the basis of cost per thousand gallons of sewage treated, about 0.55¢ is indicated.

The proposed comprehensive sewerage plan will result in the consolidation of sewage treatment plants thus reducing the number from 53 at present to 6 in the metropolitan area.

For those people who live within the study area but outside of the metropolitan area of Dallas-Fort Worth described above, the aggregate construction costs of upgrading sewage treatment facilities between now and 1990, based on 1970 construction cost estimates, is about $50,000,000. The cost per family or per thousand gallons of sewage treated would vary among the individual communities affected.

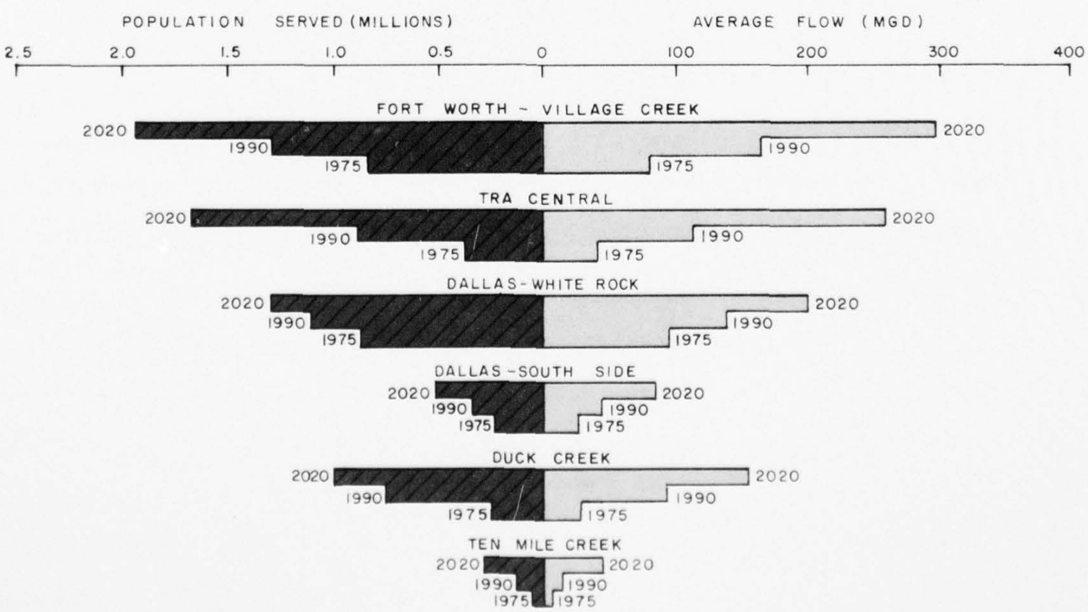


Fig. I-4 Projected Populations and Flows for Proposed Joint Plants

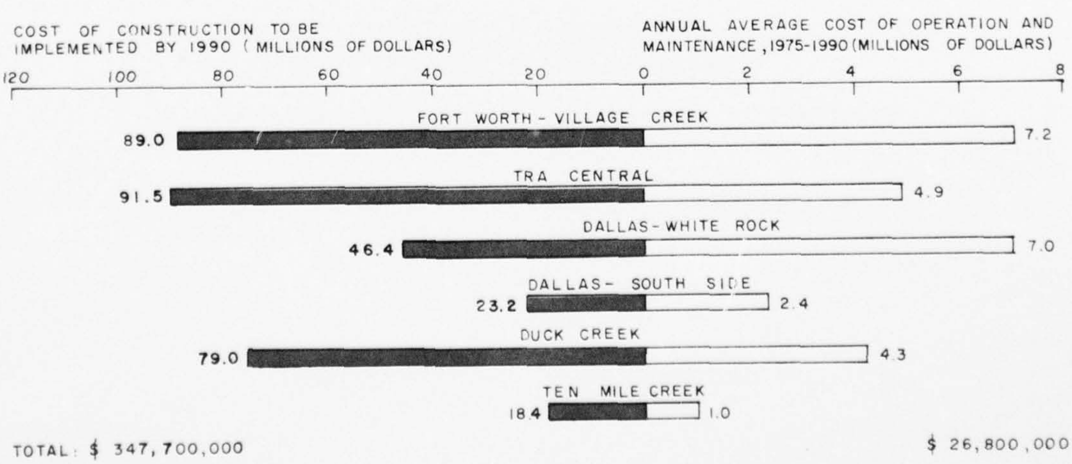


Fig. I-5 Projected Costs (1970) of Recommended Joint Systems

POLLUTION CONTROL

In addition to inadequate sewage treatment and sludge disposal the potential for polluting surface waters exists in many other forms. The installation of septic tank systems in areas where soils are inadequate results in failures and overground flow of contaminated waters into brooks, streams and water supply reservoirs. Storm runoff washes contaminants into nearby water sources; locating sanitary landfills in areas where ground water or surface water is able to leach out contaminants and flow directly into streams and water supply reservoirs is another source of pollution. Agriculture, including the fertilizing of farmlands, is suspected during wet weather periods to result in a large volume of phosphates and nutrients being washed into the streams. The uncontrolled grazing and feeding of cattle on watersheds offers a potential for pollution.

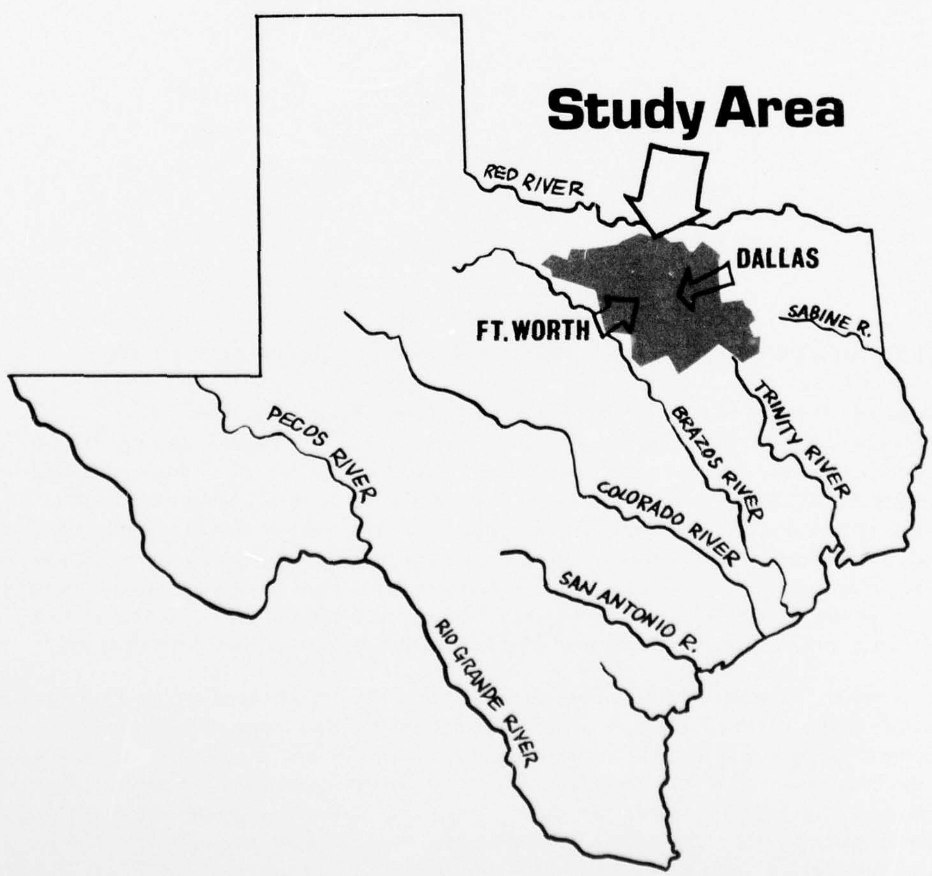
For the above reasons, the adequate collection and treatment of sewage from the municipalities in the area is only a part of the solution to adequate control of pollution. Centralization of efforts to control all types of pollution should be the goal of the people in the region.

INFILTRATION AND STORM FLOWS

Rainwater infiltration into the sewage collection systems is of a serious magnitude in several of the older and larger systems and results in poor efficiency of treatment plants and raw sewage discharges to streams. The various communities affected should consider the provision of mixed sewage and storm water detention and chlorination facilities as needed at critical locations in the systems to prevent the raw sewage discharges. Continuing programs of sewerage system maintenance and repair should be carried out to minimize infiltration. Adequate inspection, control, and the use of modern compression type joints in all sewer construction, including building connections, is essential.

WASTEWATER REUSE

As the population and water consumption increase and the surplus supply of water decreases, it will become more and more important to practice wastewater reuse to the fullest extent possible. Non-domestic uses, such as commercial and especially cooling water demands, may be satisfied by wastewater treatment (reclamation) and reuse. Water for domestic uses (after 1990) may have to be supplemented by reclaimed wastewater. The location of suitable industry, including electric power plants, adjacent to sewage treatment plants is recommended.


Study Area
RED RIVER
DALLAS
FT. WORTH
SABINE R.
PECOS RIVER
TRINITY RIVER
BRAZOS RIVER
COLORADO RIVER
SAN ANTONIO R.
RIO GRANDE RIVER

IMPLEMENTATION OF THE COMPREHENSIVE SEWERAGE PLAN

The Upper Trinty River Basin Comprehensive Sewerage Plan is a result of a concentrated study over a period of eighteen months. The results of this study clearly indicate that maximum possible cooperation and joint use of sewage collection and treatment facilities will benefit everyone concerned. The Federal Water Quality Administration has the authority to increase federal aid on those projects that are a part of a comprehensive sewerage plan. The Texas Water Quality Board encourages the consolidation of treatment facilities and requires that a new facility be consistent with a regional plan before a discharge permit is issued. The results of this study furnish a framework from which positive action can begin on implementation.

The cost estimates contained in this study should be recognized as general because of the broad scope of the study. A preliminary engineering report defining the service area,intercepting sewer routes and sizes and treatment plant size and process for each of the six recommended joint systems should be prepared as a next logical step. Such a preliminary engineering report would contain refined cost estimates for construction, operation and maintenance of proposed facilities and assist the communities involved to plan their participation in a joint treatment sytem.

Concurrent with these preliminary engineering studies, it is recommended that NCTCOG and all its member communities consider the advantages of a State Grant-In-Aid program for the construction of water pollution abatement facilities. Such a State program (contributing of 25% or more of eligible project costs) would increase the amount of money available to the local communities on eligible projects from a present maximum of 30% (Federal) to about 80% (Federal and State). The Federal Water Quality Act provides increased benefits to states which have their own grant program underway and many states in the country have taken advantage of this. The State of Texas should do likewise.

The TWQB has recently funded NCTCOG to develop an implementation program providing details of the regional organization and its powers. This program is scheduled for completion in March 1971.

PRESENTATION OF THE PLAN

Concerted efforts have been made by the NCTCOG to acquaint all member communities and interested agencies with the Comprehensive Sewerage Plan. Notices were sent to local, State and Federal officials and interested citizens in North Central Texas in advance advising them of the schedule of report presentations. To acquaint as many persons as possible with the contents of the report and to obtain their comments, a number of presentations have been made including those to the following:

Federal Water Quality Administration;

Texas Water Quality Board;

Fort Worth City Council;

Dallas City Council;

Area upstream of Dallas South Side Plant;

Area upstream of Dallas White Rock Plant;

Area upstream of Garland Duck Creek Plant;

Area upstream of Fort Worth-Village Creek Plant;

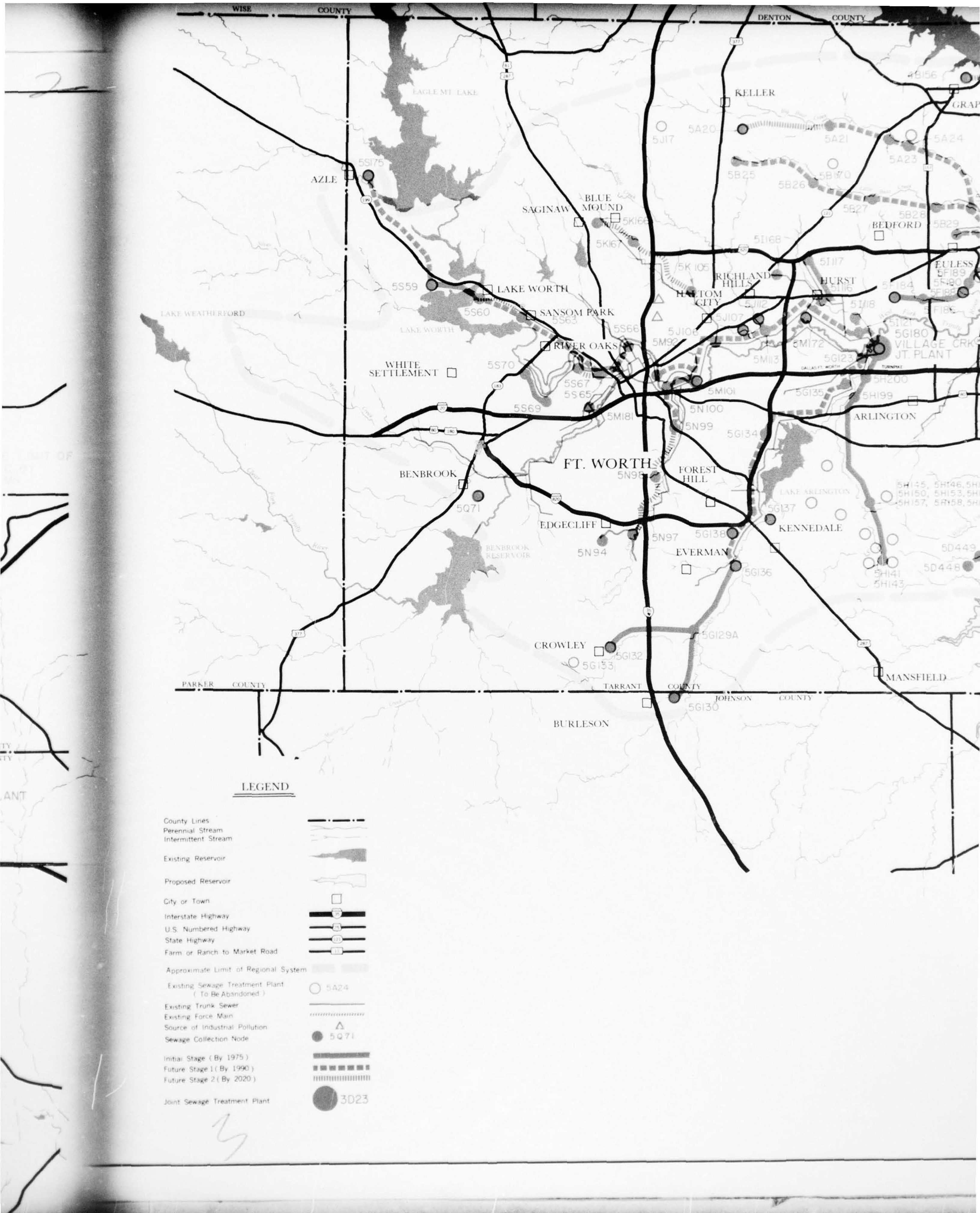
Area upstream of TRA Ten Mile Creek Plant;

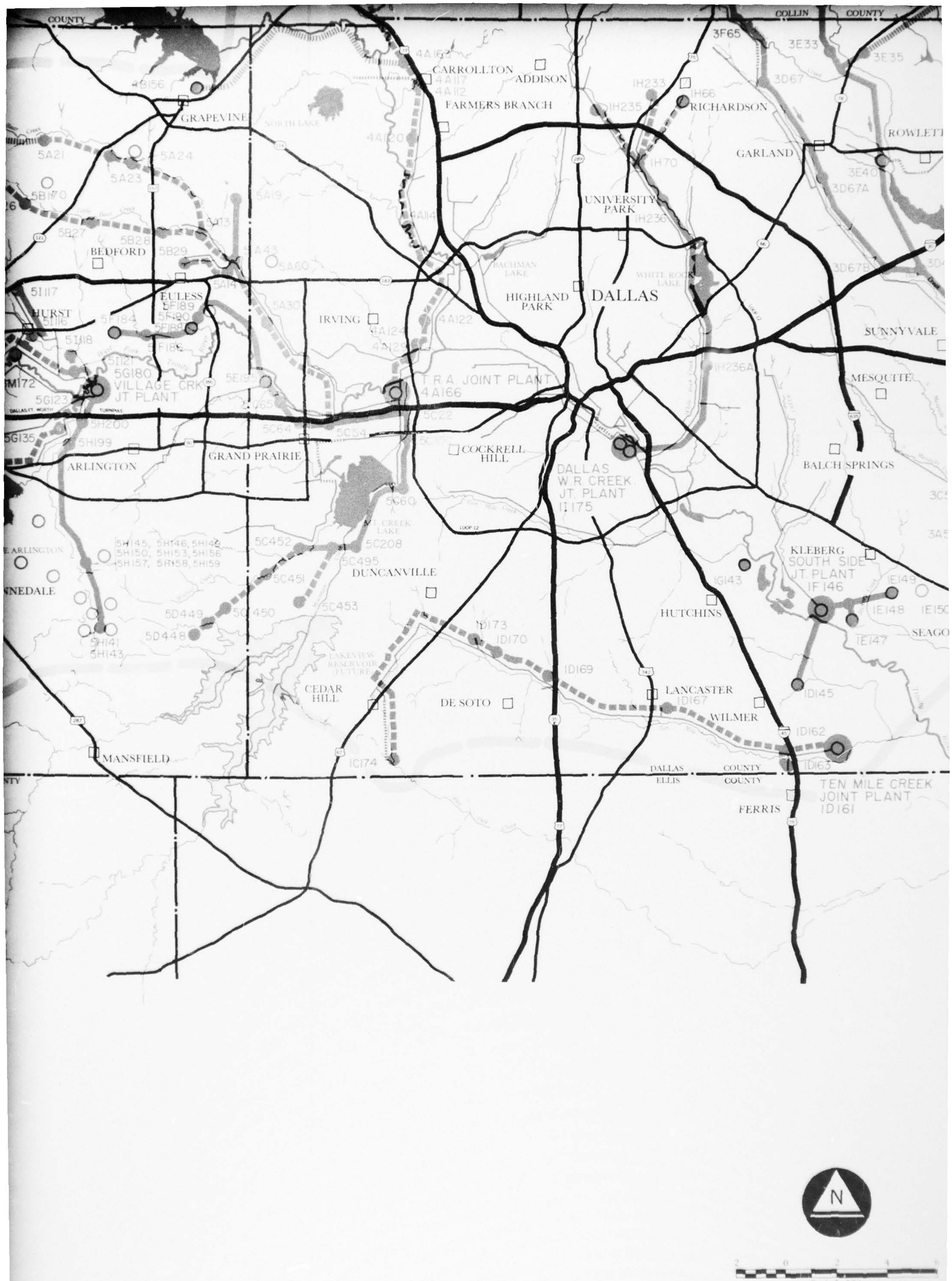
Area upstream of the TRA Central Plant;

Areas outside Dallas and Tarrant Counties.

WISE COUNTY
DENTON COUNTY
GRAPEVINE RESERVOIR
EAGLE MT. LAKE
KELLER
GRAPEVINE
AZLE
SAGINAW
BLUE MOUND
BEDFORD
EULESS
RICHLAND HILLS
HURST
HALTOM CITY
LAKE WORTH
SANSOM PARK
LAKE WEATHERFORD
RIVER OAKS
WHITE SETTLEMENT
VILLAGE CRK JT. PLANT
ARLINGTON
FT. WORTH
BENBROOK
FOREST HILL
LAKE ARLINGTON
KENNEDALE
EDGECLIFF
EVERMAN
BENBROOK RESERVOIR
CROWLEY
MANSFIELD
PARKER COUNTY
TARRANT COUNTY
JOHNSON COUNTY
BURLESON
5J17
5A20
5A21
5A23
5A24
4B156
5B25
5B26
5B27
5B28
5B29
5S175
5K166
5K167
5I168
5K105
5I117
5I116
5I118
5I121
5F189
5F190
5F188
5F184
5S59
5S60
5S63
5S66
5J106
5J107
5J112
5M172
5G180
5G123
5M113
5M99
5S70
5S67
5S65
5S69
5M181
5M101
5N100
5N99
5G135
5H200
5H199
5G134
5N98
5Q71
5G137
5H145, 5H146, 5H149
5H150, 5H153, 5H156
5H157, 5H158, 5H159
5N97
5N94
5G138
5G136
5D449
5D448
5H141
5H143
5G129A
5G132
5G133
5G130

McKINNEY NORTH
3H3
McKINNEY
McKINNEY SOUTH
3H24
GARZA-LITTLE ELM RESERVOIR
LAVON RESERVOIR
ALLEN
3E25
LEWISVILLE
4A81
PLANO
3F69
3E26
3E29
3E31
WYLIE
3G34
COLLIN COUNTY
IH64
3F65
3E33
3E35
3B16
ROCKWALL
4A163
CARROLLTON
4A117
4A112
ADDISON
FARMERS BRANCH
IH233
IH66
RICHARDSON
3D67
GRAPEVINE
NORTH LAKE
IH235
4A120
ROWLETT
GARLAND
IH70
3E40
3D67A
5A19
UNIVERSITY PARK
IH236
5A13
4A114
5A43
5A60
5A14
3D67B
3D45
LAKE RAY HUBBARD
5A30
BACHMAN LAKE
WHITE ROCK LAKE
HIGHLAND PARK
DALLAS
3B20
ROCKWALL COUNTY
KAUFMAN COUNTY
IRVING
4A122
4A124
4A125
SUNNYVALE
DUCK CREEK JOINT P
3D23
5E195
IH236A
T R A JOINT PLANT
4A166
MESQUITE
5C64
5C22
3C49
GRAND PRAIRIE
5C54
5C350
COCKRELL HILL
DALLAS
W R CREEK
JT. PLANT
1I 175
BALCH SPRINGS
3C53
5C60
3C54
5C452
5C208
3A57
5C451
5C495
DUNCANVILLE
KLEBERG
SOUTH SIDE
JT. PLANT
1F146
1G143
1E149
3A58
5C450
5C453
HUTCHINS
1E148
1E150
SEAGOVILLE
1D173
1D170
1E147
LAKEVIEW RESERVOIR (FUTURE)
1D169
CEDAR HILL
1D145
LANCASTER
1D167
DE SOTO
WILMER
1D162
1C174
1D163
DALLAS COUNTY
ELLIS COUNTY
TEN MILE CREEK
JOINT PLANT
1D161
FERRIS


WISE COUNTY
DENTON COUNTY
EAGLE MT. LAKE
KELLER
GRAP
AZLE
5S175
SAGINAW
BLUE MOUND
5K166
5K167
5J17
5A20
5A21
5A23
5A24
5B25
5B26
5B170
5B27
5B28
5B29
BEDFORD
5I168
5K105
RICHLAND HILLS
HALTOM CITY
5I117
HURST
5I116
5I118
EULESS
5F189
5F190
5F184
5F185
5S59
LAKE WORTH
SANSOM PARK
5S60
5S63
LAKE WEATHERFORD
5J112
5J107
5J106
5S66
5M90
5M172
5I121
5G180
VILLAGE CRK
JT. PLANT
RIVER OAKS
5M113
5G123
WHITE SETTLEMENT
5S70
5S67
5S65
5M101
5N100
5G135
5H200
5H199
5S69
5M181
5N99
5G134
ARLINGTON
DALLAS-FT. WORTH TURNPIKE
FT. WORTH
BENBROOK
5N98
FOREST HILL
5Q71
LAKE ARLINGTON
5H145, 5H146, 5H
5H150, 5H153, 5H
5H157, 5H158, 5H
EDGECLIFF
5G137
KENNEDALE
5N94
5N97
5G138
EVERMAN
BENBROOK RESERVOIR
5D449
5D448
5G136
5H141
5H143
5G129A
CROWLEY
5G132
5G133
MANSFIELD
PARKER COUNTY
TARRANT COUNTY
JOHNSON COUNTY
5G130
BURLESON
LEGEND
County Lines
Perennial Stream
Intermittent Stream
Existing Reservoir
Proposed Reservoir
City or Town
Interstate Highway
U.S. Numbered Highway
State Highway
Farm or Ranch to Market Road
Approximate Limit of Regional System
Existing Sewage Treatment Plant (To Be Abandoned)
5A24
Existing Trunk Sewer
Existing Force Main
Source of Industrial Pollution
Sewage Collection Node
5Q71
Initial Stage (By 1975)
Future Stage 1 (By 1990)
Future Stage 2 (By 2020)
Joint Sewage Treatment Plant
3D23

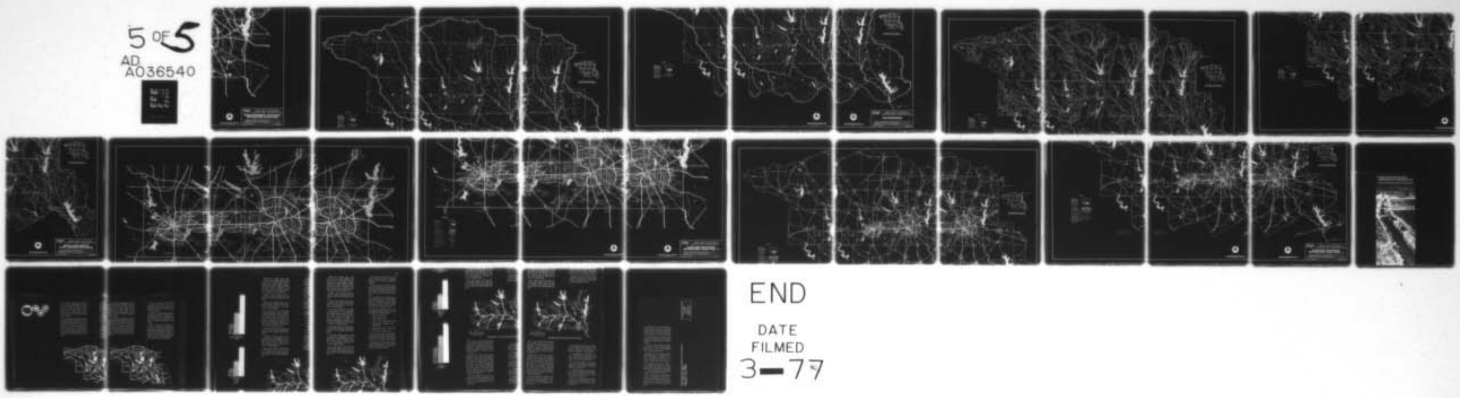

COUNTY
COLLIN COUNTY
GRAPEVINE
CARROLLTON
ADDISON
FARMERS BRANCH
RICHARDSON
GARLAND
ROWLETT
UNIVERSITY PARK
BEDFORD
EULESS
HURST
IRVING
HIGHLAND PARK
DALLAS
SUNNYVALE
MESQUITE
VILLAGE CRK JT. PLANT
T.R.A. JOINT PLANT
ARLINGTON
GRAND PRAIRIE
COCKRELL HILL
DALLAS W.R. CREEK JT. PLANT
BALCH SPRINGS
KLEBERG SOUTH SIDE JT. PLANT
DUNCANVILLE
HUTCHINS
CEDAR HILL
DE SOTO
LANCASTER
WILMER
MANSFIELD
DALLAS COUNTY
ELLIS COUNTY
TEN MILE CREEK JOINT PLANT
FERRIS
N
Scale In Miles

4

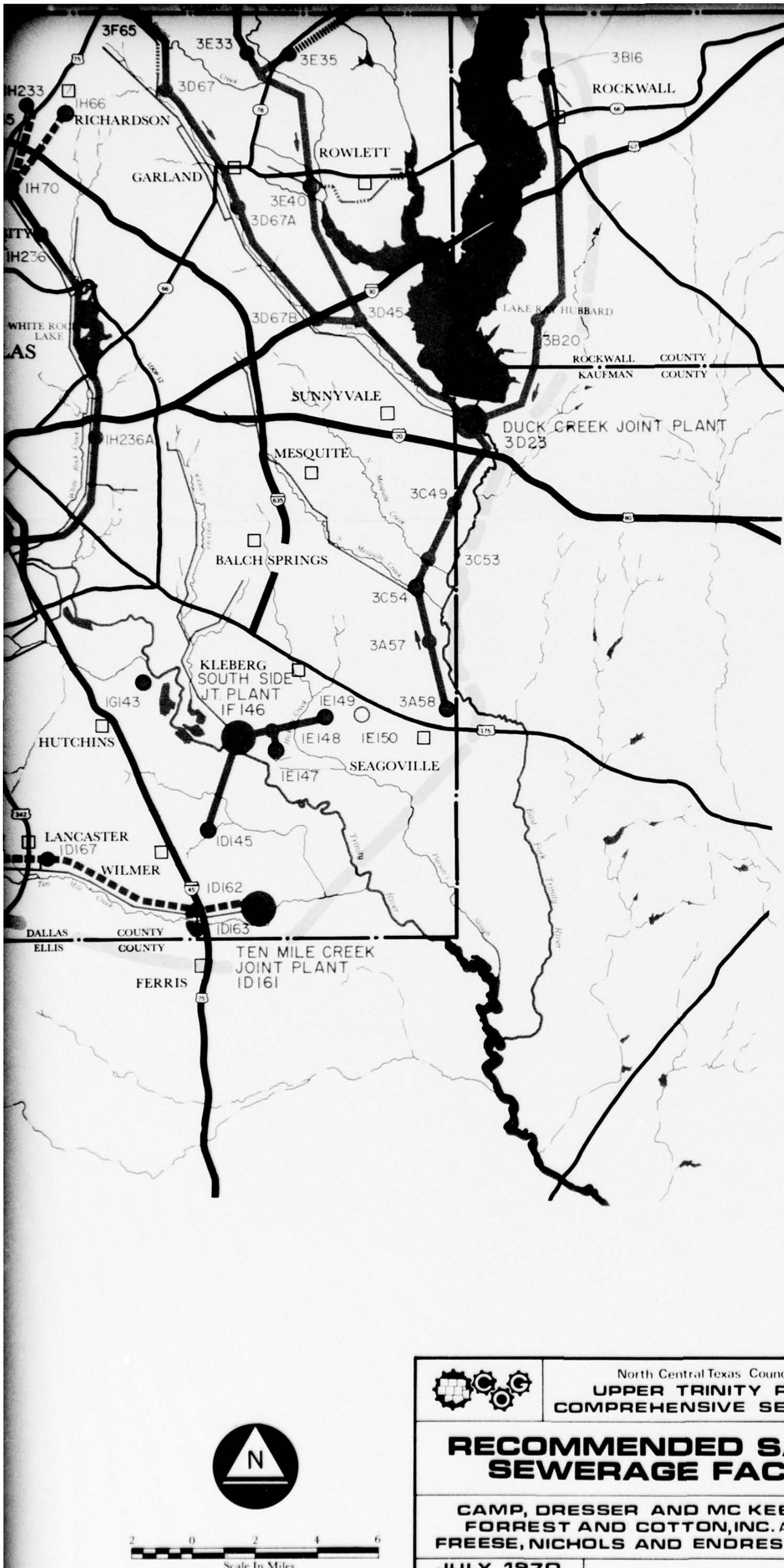
AD-A036 540 CAMP DRESSER AND MCKEE BOSTON MASS F/G 13/2
UPPER TRINITY RIVER BASIN COMPREHENSIVE SEWERAGE PLAN. VOLUME I--ETC(U)
JUL 70

UNCLASSIFIED NL

5 OF 5
AD
A036540



END
DATE
FILMED
3-77



North Central Texas Council Of Governments

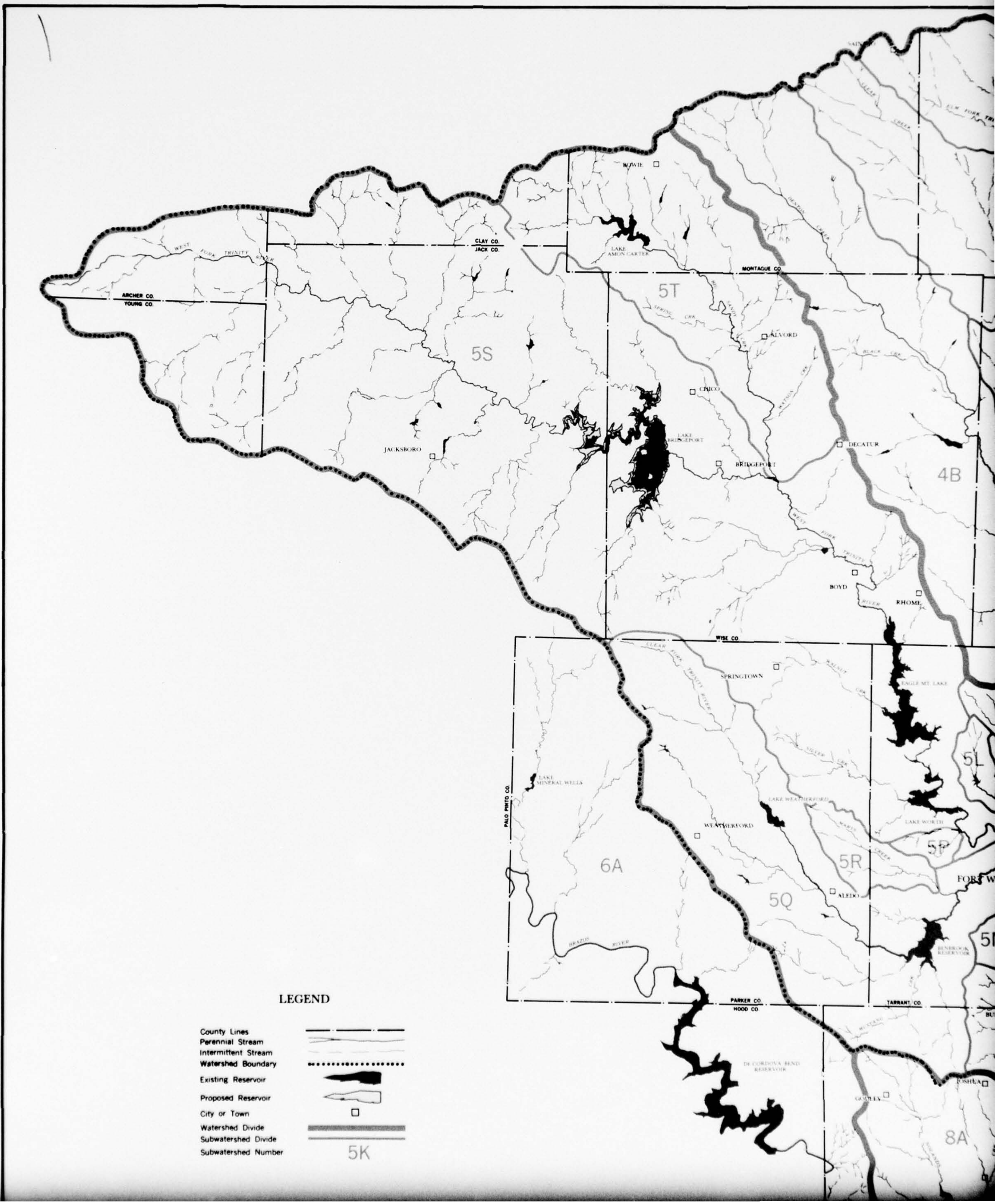
UPPER TRINITY RIVER BASIN
COMPREHENSIVE SEWERAGE PLAN

RECOMMENDED SANITARY SEWERAGE FACILITIES

CAMP, DRESSER AND MC KEE General Consultants
FORREST AND COTTON, INC. Associate Consultants
FREESE, NICHOLS AND ENDRESS Associate Consultants

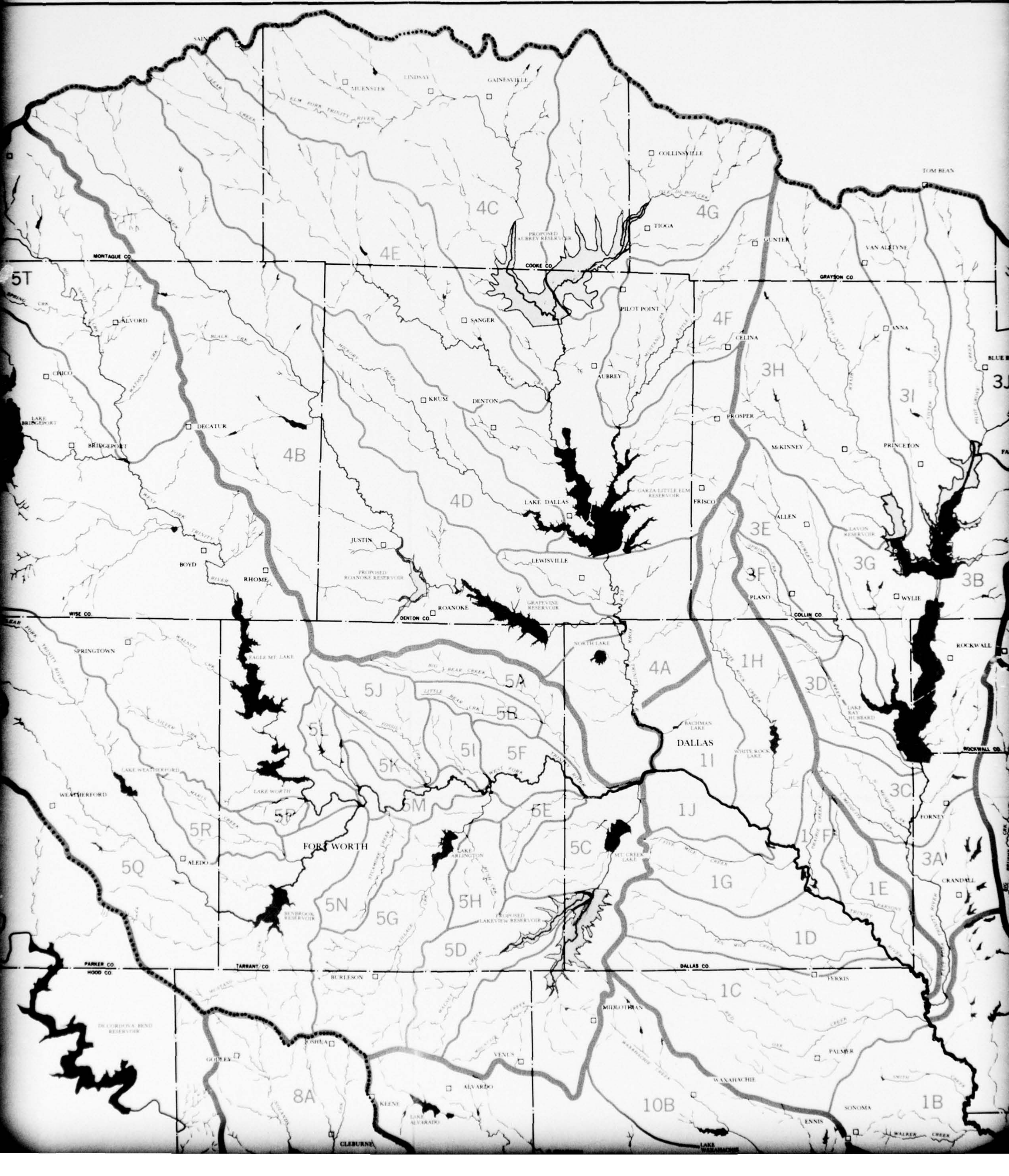
JULY 1970 | FIG. X-1

5



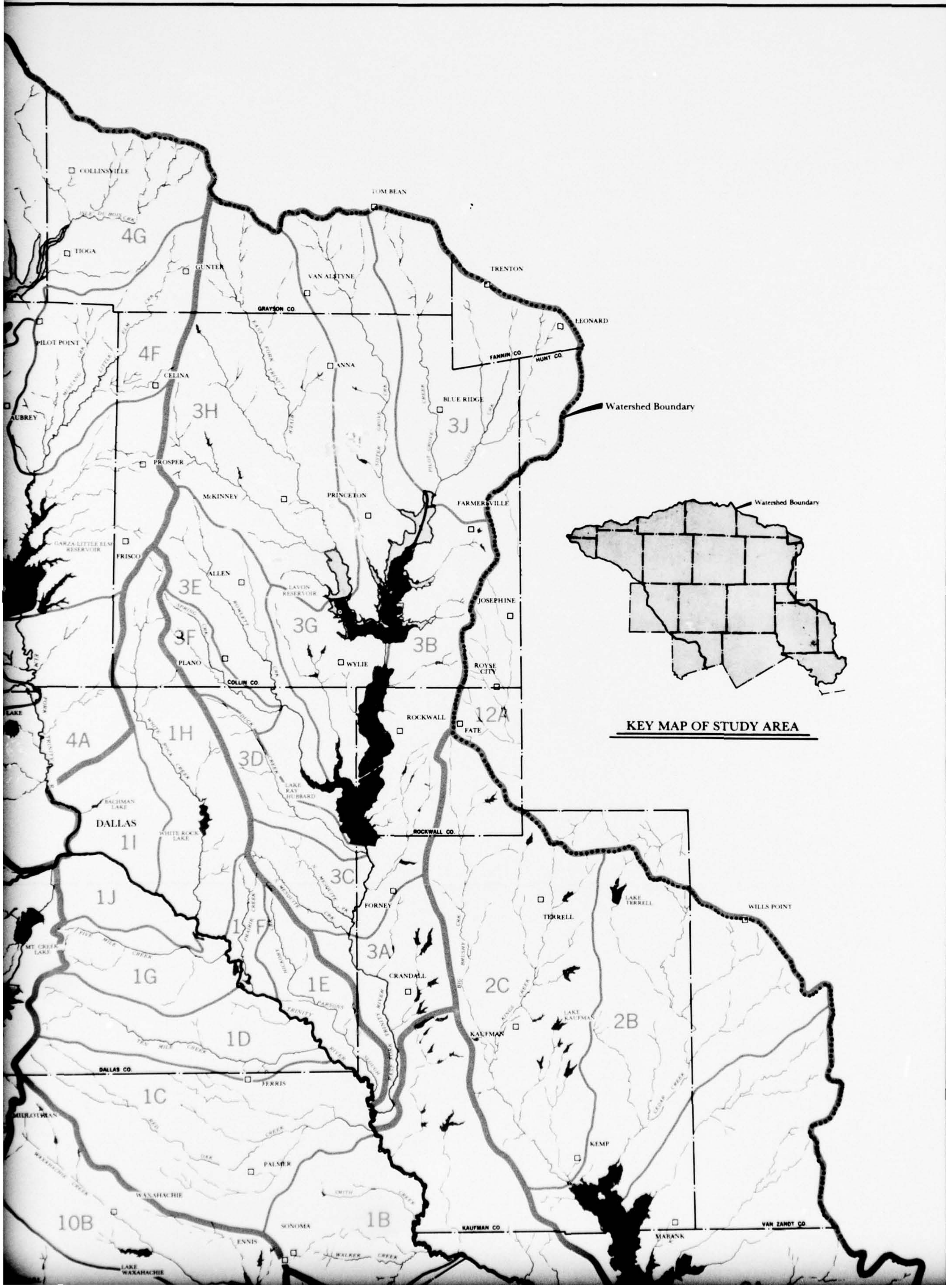
BOWIE
LAKE AMON CARTER
CLAY CO.
JACK CO.
MONTAGUE CO.
WEST FORK TRINITY RIVER
ARCHER CO.
YOUNG CO.
5T
SPRING CRK
ALVORD
BLACK CRK
DENTON CREEK
CLEAR CREEK
5S
CHICO
LAKE BRIDGEPORT
DECATUR
BRIDGEPORT
JACKSBORO
4B
BOYD
RHOME
WISE CO.
CLEAR FORK TRINITY RIVER
SPRINGTOWN
WALNUT CRK
EAGLE MT. LAKE
5L
LAKE MINERAL WELLS
PALO PINTO CO.
SILVER CRK
LAKE WEATHERFORD
WEATHERFORD
LAKE WORTH
5P
5R
6A
5Q
ALEDO
BRAZOS RIVER
BENBROOK RESERVOIR
PARKER CO.
HOOD CO.
TARRANT CO.
DE CORDOVA BEND RESERVOIR
JOSHUA
GODLEY
8A
LEGEND
County Lines
Perennial Stream
Intermittent Stream
Watershed Boundary
Existing Reservoir
Proposed Reservoir
City or Town
Watershed Divide
Subwatershed Divide
Subwatershed Number
5K

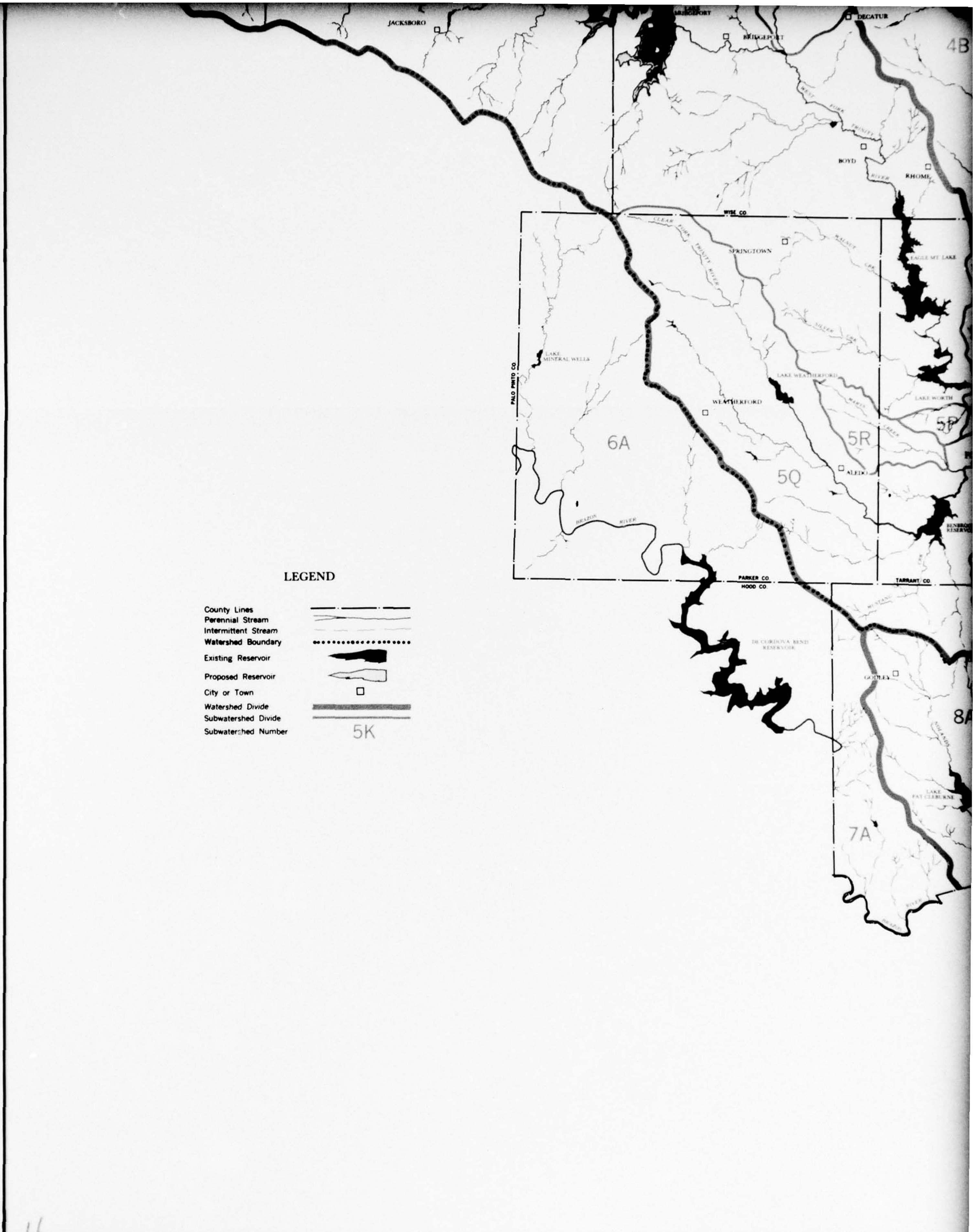
2



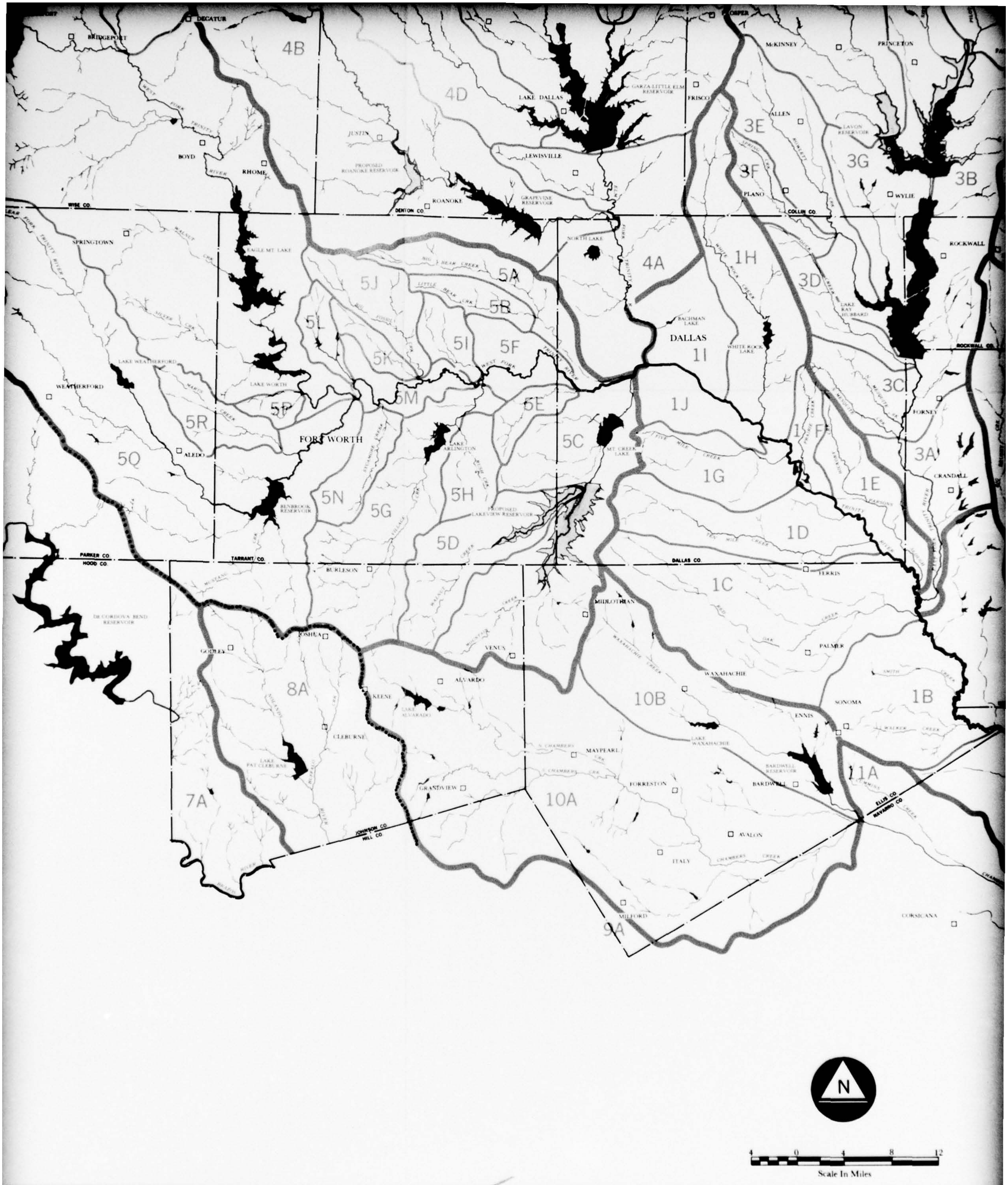
MUENSTER
LINDSAY
GAINESVILLE
ELM FORK TRINITY RIVER
CLEAR CREEK
COLLINSVILLE
TOM BEAN
4C
4G
4E
TIOGA
PROPOSED AUBREY RESERVOIR
GUNTER
VAN ALSTYNE
MONTAGUE CO
COOKE CO
GRAYSON CO
5T
ALVORD
SANGER
PILOT POINT
4F
CELINA
ANNA
BLUE RIDGE
CHICO
AUBREY
3H
3J
3I
KRUM
DENTON
LAKE BRIDGEPORT
DECATUR
PROSPER
BRIDGEPORT
4B
McKINNEY
PRINCETON
GARZA-LITTLE ELM RESERVOIR
FRISCO
4D
LAKE DALLAS
ALLEN
3E
LAVON RESERVOIR
JUSTIN
BOYD
LEWISVILLE
3G
3F
3B
RHOME
PROPOSED ROANOKE RESERVOIR
WYLIE
PLANO
ROANOKE
GRAPEVINE RESERVOIR
WISE CO
DENTON CO
COLLIN CO
SPRINGTOWN
NORTH LAKE
ROCKWALL
EAGLE MT. LAKE
BIG BEAR CREEK
4A
1H
5A
5J
LITTLE BEAR CRK
3D
5B
LAKE RAY HUBBARD
5L
BACHMAN LAKE
DALLAS
5I
5F
WHITE ROCK LAKE
1I
ROCKWALL CO
LAKE WEATHERFORD
5K
LAKE WORTH
WEST FORK
3C
WEATHERFORD
5P
5M
5E
1J
FORNEY
5R
FORT WORTH
LAKE ARLINGTON
5C
MT. CREEK LAKE
1F
3A
ALEDO
5Q
1G
CRANDALL
1E
BENBROOK RESERVOIR
5N
5G
5H
PROPOSED LAKEVIEW RESERVOIR
1D
5D
PARKER CO
HOOD CO
TARRANT CO
DALLAS CO
BURLESON
FERRIS
1C
MIDLOTHIAN
DE CORDOVA BEND RESERVOIR
JOSHUA
GODLEY
VENUS
PALMER
WAXAHACHIE
ALVARADO
8A
KEENE
LAKE ALVARADO
10B
SONOMA
1B
ENNIS
CLEBURNE
LAKE WAXAHACHIE
WALKER CREEK

3


COLLINSVILLE
TOM BEAN
TIOGA
4G
GUNTER
VAN ALSTYNE
TRENTON
GRAYSON CO.
LEONARD
PILOT POINT
4F
CELINA
ANNA
FANNIN CO.
HUNT CO.
BLUE RIDGE
Watershed Boundary
AUBREY
3H
3J
PROSPER
McKINNEY
PRINCETON
FARMERSVILLE
GARZA-LITTLE ELM RESERVOIR
FRISCO
ALLEN
3E
LAVON RESERVOIR
JOSEPHINE
3G
3F
3B
PLANO
WYLIE
ROYSE CITY
COLLIN CO.
ROCKWALL
12A
FATE
4A
1H
3D
LAKE RAY HUBBARD
BACHMAN LAKE
DALLAS
1I
WHITE ROCK LAKE
ROCKWALL CO.
3C
1J
FORNEY
TERRELL
LAKE TERRELL
WILLS POINT
MT. CREEK LAKE
1F
3A
1G
CRANDALL
1E
2C
LAKE KAUFMAN
KAUFMAN
2B
1D
DALLAS CO.
FERRIS
1C
KEMP
PALMER
WAXAHACHIE
10B
SONOMA
1B
KAUFMAN CO.
VAN ZANDT CO.
MABANK
ENNIS
LAKE WAXAHACHIE
Watershed Boundary
KEY MAP OF STUDY AREA

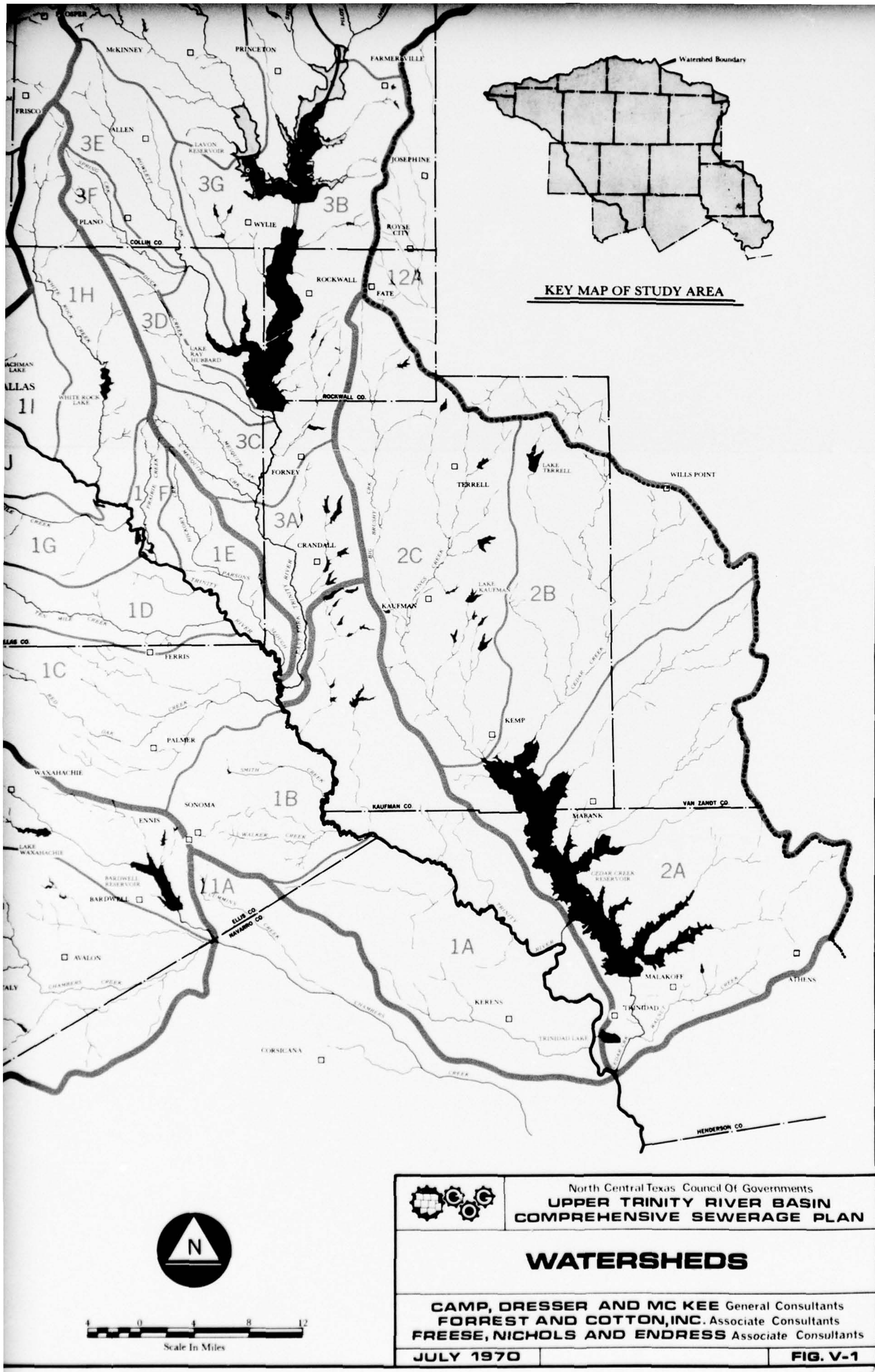

JACKSBORO
LAKE BRIDGEPORT
BRIDGEPORT
DECATUR
4B
WEST FORK TRINITY RIVER
BOYD
RHOME
WISE CO
CLEAR FORK TRINITY RIVER
SPRINGTOWN
WALNUT CRK
EAGLE MT LAKE
SILVER CR
LAKE MINERAL WELLS
PALO PINTO CO
LAKE WEATHERFORD
WEATHERFORD
LAKE WORTH
MARYS CREEK
5P
5R
6A
5Q
ALEDO
BRAZOS RIVER
BENBROOK RESERVOIR
PARKER CO
HOOD CO
TARRANT CO
DE CORDOVA BEND RESERVOIR
GODLEY
8A
LAKE PAT CLEBURNE
7A
LEGEND
County Lines
Perennial Stream
Intermittent Stream
Watershed Boundary
Existing Reservoir
Proposed Reservoir
City or Town
Watershed Divide
Subwatershed Divide
Subwatershed Number
5K

4



DECATUR
BRIDGEPORT
BOYD
RHOME
LAKE DALLAS
GARZA-LITTLE ELM RESERVOIR
FRISCO
McKINNEY
PRINCETON
ALLEN
LAVON RESERVOIR
LEWISVILLE
JUSTIN
PROPOSED ROANOKE RESERVOIR
ROANOKE
GRAPEVINE RESERVOIR
PLANO
WYLIE
WISE CO.
DENTON CO.
COLLIN CO.
ROCKWALL
SPRINGTOWN
EAGLE MT. LAKE
NORTH LAKE
BACHMAN LAKE
DALLAS
WHITE ROCK LAKE
LAKE RAY HUBBARD
ROCKWALL CO.
LAKE WEATHERFORD
WEATHERFORD
LAKE WORTH
FORT WORTH
ALEDO
LAKE ARLINGTON
MT. CREEK LAKE
FORNEY
CRANDALL
BENBROOK RESERVOIR
PROPOSED LAKEVIEW RESERVOIR
PARKER CO.
HOOD CO.
TARRANT CO.
DALLAS CO.
BURLESON
FERRIS
MIDLOTHIAN
DE CORDOVA BEND RESERVOIR
JOSHUA
GODLEY
VENUS
PALMER
ALVARADO
KEENE
LAKE ALVARADO
WAXAHACHIE
CLEBURNE
SONOMA
ENNIS
LAKE WAXAHACHIE
LAKE PAT CLEBURNE
MAYPEARL
BARDWELL RESERVOIR
BARDWELL
GRANDVIEW
FORRESTON
ELLIS CO.
NAVARRO CO.
JOHNSON CO.
HILL CO.
AVALON
ITALY
MILFORD
CORSICANA
4B
4D
3E
3F
3G
3B
4A
1H
3D
5J
5A
5B
5L
5I
5F
5K
1I
5M
5E
1J
3C
5P
5R
1F
3A
5C
1G
1E
5Q
5N
5H
5G
1D
5D
1C
8A
10B
1B
11A
10A
7A
9A
N
4
0
4
8
12
Scale In Miles

5



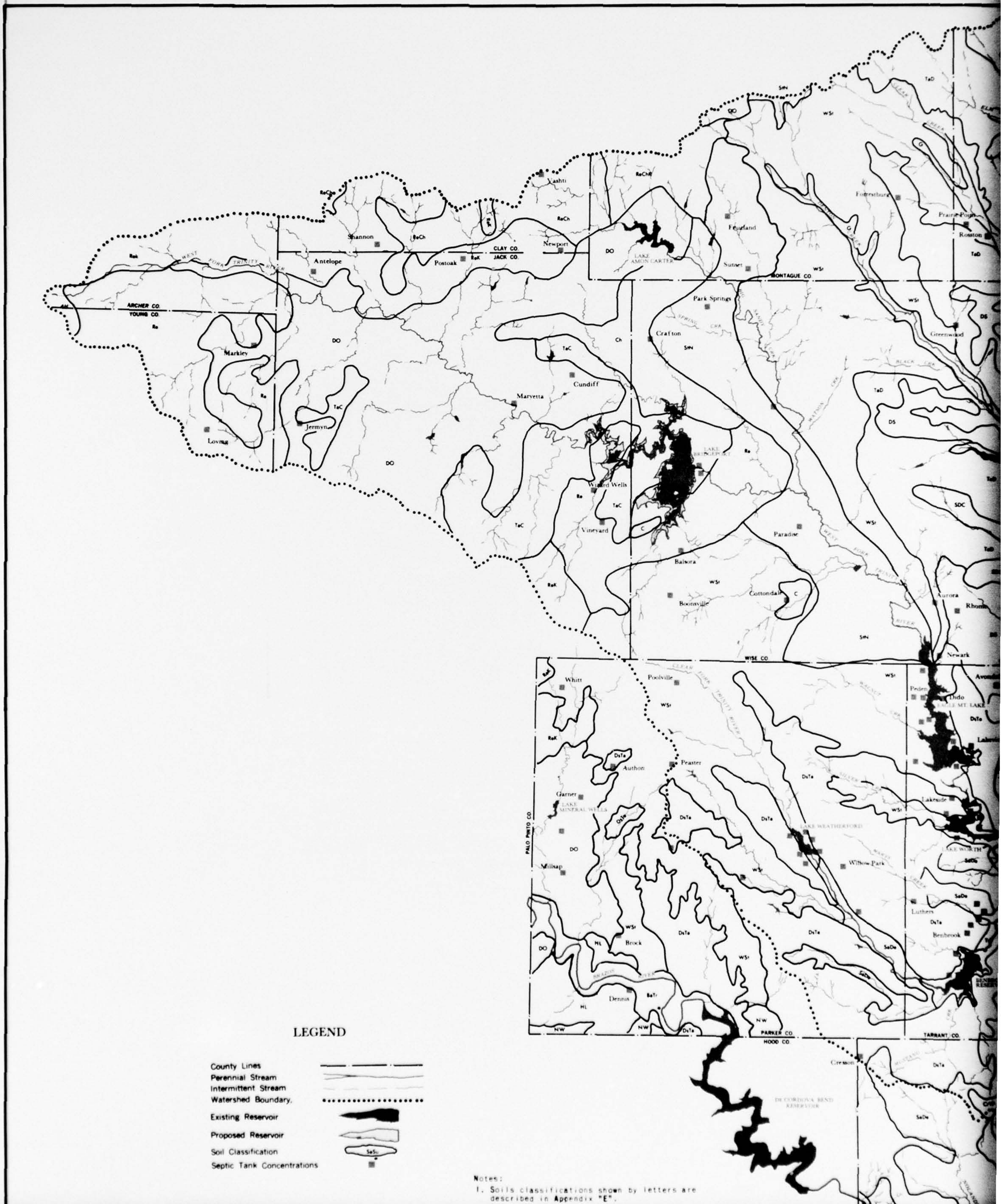
North Central Texas Council Of Governments

UPPER TRINITY RIVER BASIN
COMPREHENSIVE SEWERAGE PLAN

WATERSHEDS

CAMP, DRESSER AND MC KEE General Consultants
FORREST AND COTTON, INC. Associate Consultants
FREESE, NICHOLS AND ENDRESS Associate Consultants

JULY 1970 | FIG. V-1

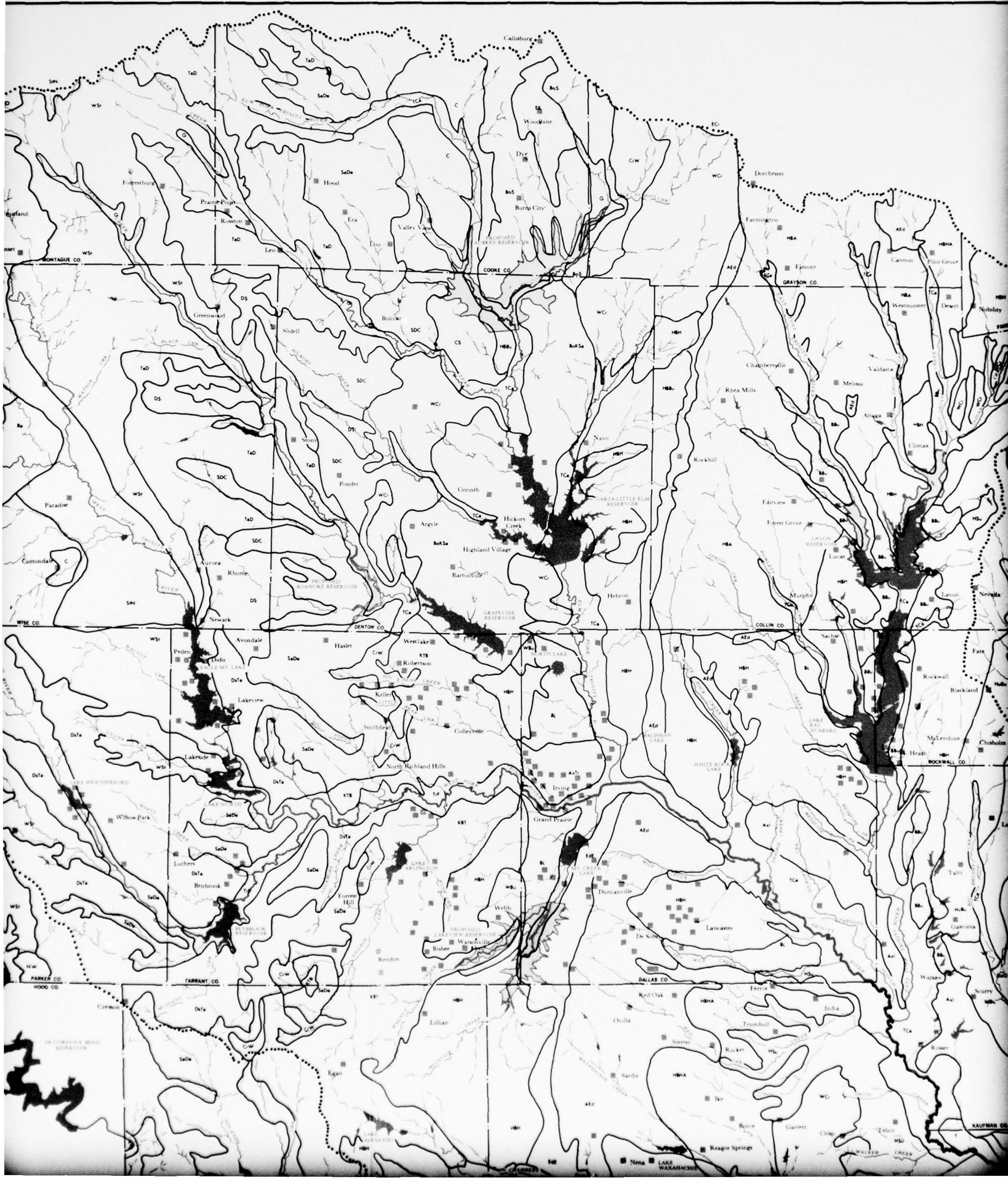


Notes:

1. Soils classifications shown by letters are described in Appendix "E".
2. Soils data are based on generalized soil maps compiled by Soil Conservation Service, U. S. Department of Agriculture, and Texas Agricultural

1

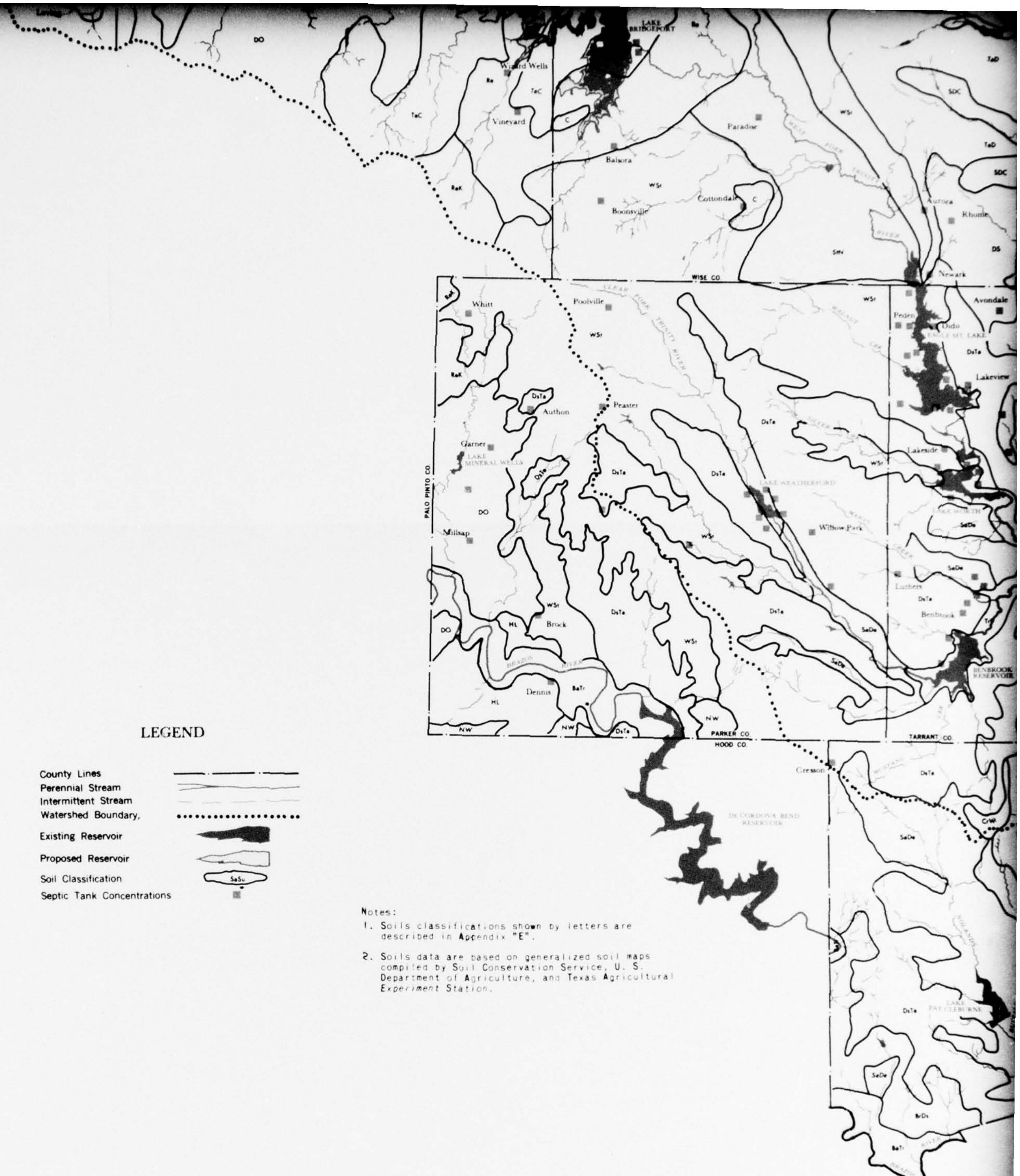
2



Callisburg
Woodbine
Dye
Burns City
Hood
Era
Valley View
PROPOSED AUBREY RESERVOIR
Forestburg
Prairie Point
Rosston
Leo
Dorchester
Farmington
Elmont
Cannon
Pilot Grove
Westminster
Desert
Nobility
MONTAGUE CO.
COOKE CO.
GRAYSON CO.
Greenwood
Slidell
Bolivar
Chambersville
Melissa
Valdasta
Altoga
Climax
Rhea Mills
Rockhill
Navo
Stony
Ponder
Corinth
Paradise
Hickory Creek
GARZA LITTLE ELM RESERVOIR
Argyle
Highland Village
Bartonville
Fairview
Forest Grove
LAVON RESERVOIR
Lucas
Cottondale
Aurora
Rhome
PROPOSED ROANOKE RESERVOIR
GRAPEVINE RESERVOIR
Hebron
Murphy
Lavon
Nevada
Newark
WISE CO.
DENTON CO.
COLLIN CO.
Avondale
Haslet
Westlake
Robertson
Keller
NORTH LAKE
Peden
Dido
EAGLE MT. LAKE
Lakeview
Sachse
Fate
Rockwall
Blackland
Smithfield
Colleyville
BACHMAN LAKE
LAKE RAY HUBBARD
McLendon
Chisholm
Heath
ROCKWALL CO.
Lakeside
North Richland Hills
WHITE ROCK LAKE
LAKE WEATHERFORD
LAKE WORTH
Irving
Willow Park
Grand Prairie
Luthers
Benbrook
LAKE ARLINGTON
MT. CREEK LAKE
Duncanville
Forrest Hill
Talty
Gastonia
Webb
BENBROOK RESERVOIR
PROPOSED LAKEVIEW RESERVOIR
Watsonville
Bisbee
Rendon
De Soto
Lancaster
Wazaw
Scurry
PARKER CO.
HOOD CO.
TARRANT CO.
DALLAS CO.
Red Oak
Ferris
India
Cresson
Lillian
Ovilla
Trumbull
DECORDOVA BEND RESERVOIR
Sterrett
Rocket
Rosser
Egan
Sardis
Ike
Bovce
Garrett
Crisp
Telico
KAUFMAN CO.
Reagor Springs
Nena
LAKE WAXAHACHIE

3


Watershed Boundary
KEY MAP OF STUDY AREA
GRAYSON CO.
FANNIN CO.
HUNT CO.
COLLIN CO.
ROCKWALL CO.
DALLAS CO.
KAUFMAN CO.
VAN ZANDT CO.
Dorchester
Farmington
Elmont
Cannon
Pilot Grove
Westminster
Desert
Nobility
Pike
Chambersville
Rhea Mills
Melissa
Valdasta
Altoga
Climax
Navo
Rockhill
GARZA-LITTLE ELM RESERVOIR
Fairview
Forest Grove
LAVON RESERVOIR
Lucas
Murphy
Lavon
Nevada
Hebron
Sachse
Fate
Rockwall
Blackland
LAKE RAY HUBBARD
McLendons
Chisholm
Heath
BACHMAN LAKE
WHITE ROCK LAKE
Lawrence
LAKE TERRELL
Elmo
Talty
Duncanville
Lancaster
De Soto
Gastonia
LAKE KAUFMAN
Ola
Wilmer
Myrtle Springs
Ferris
Red Oak
India
Ovilla
Trumbull
Scurry
Jiba
Wise
Prairieville
Sterret
Rocket
Rosser
Sardis
Ike
Boyce
Garrett
Crisp
Telico
Reagor Springs
Nena
LAKE WAXAHACHIE



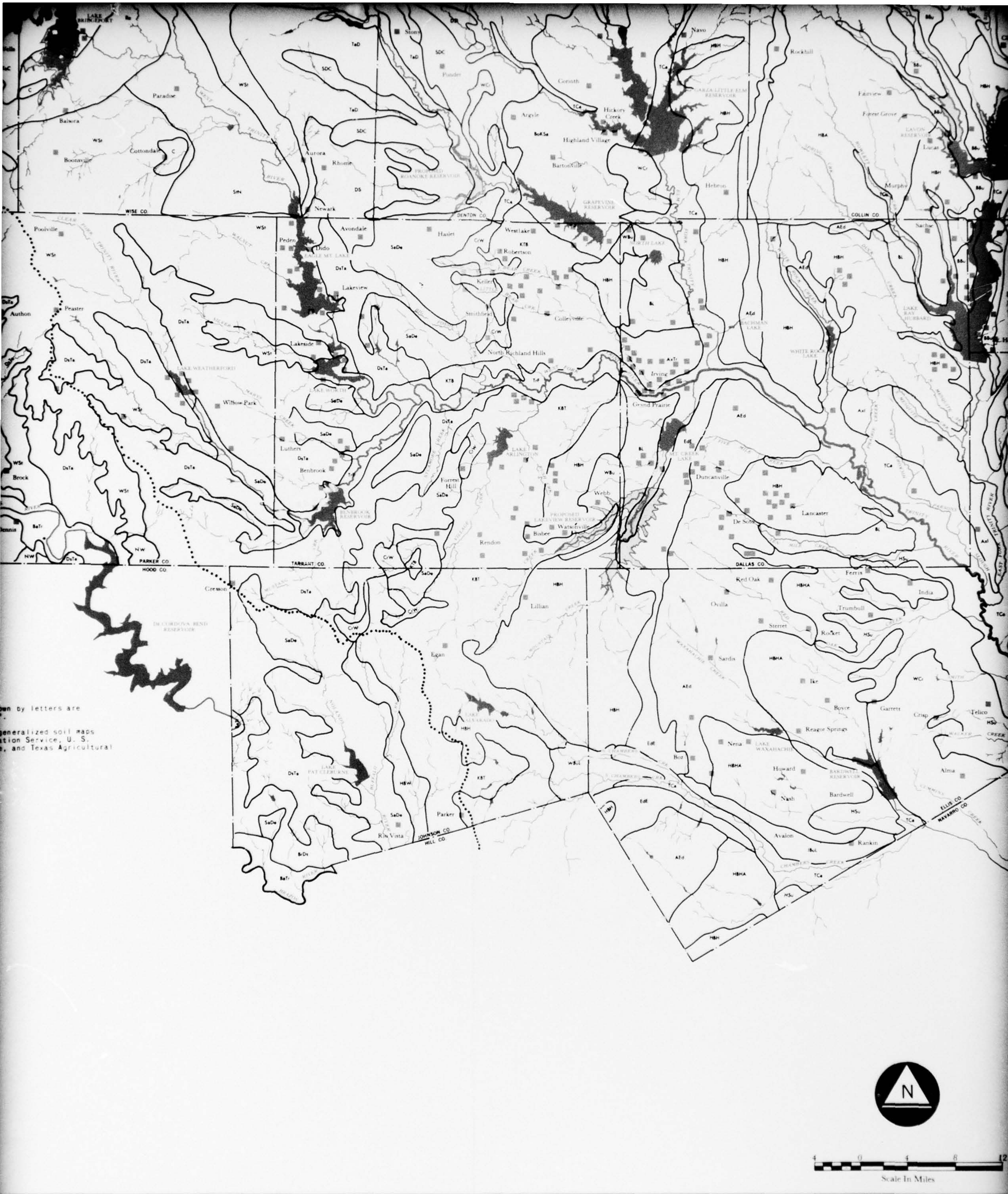
LEGEND

County Lines
Perennial Stream
Intermittent Stream
Watershed Boundary,
Existing Reservoir
Proposed Reservoir
Soil Classification
Septic Tank Concentrations

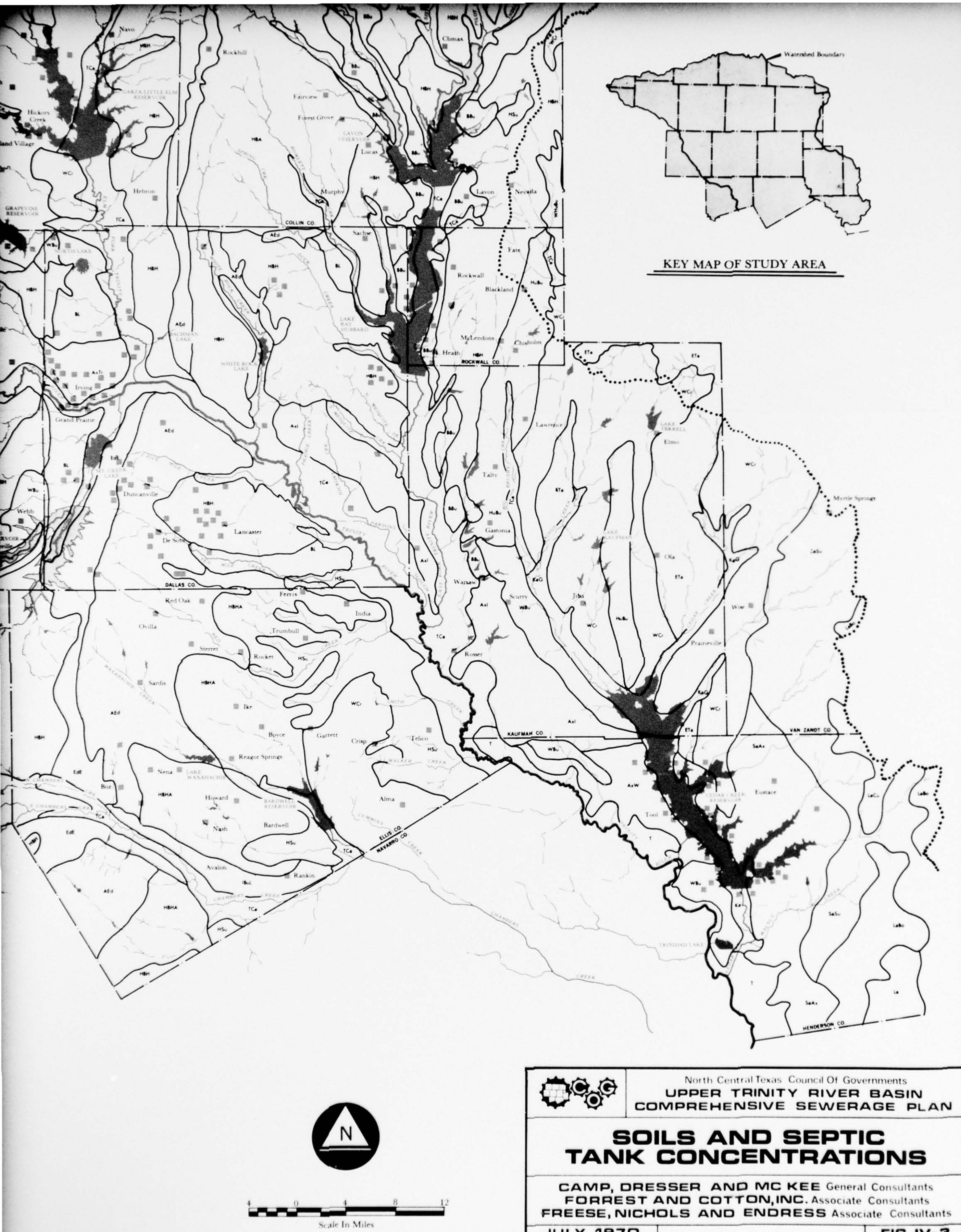
Notes:

1. Soils classifications shown by letters are described in Appendix "E".

2. Soils data are based on generalized soil maps compiled by Soil Conservation Service, U. S. Department of Agriculture, and Texas Agricultural *Experiment Station*.



own by letters are
generalized soil maps
ation Service, U. S.
e, and Texas Agricultural
WISE CO.
DENTON CO.
COLLIN CO.
PARKER CO.
HOOD CO.
TARRANT CO.
DALLAS CO.
JOHNSON CO.
HILL CO.
ELLIS CO.
NAVARRO CO.
LAKE BRIDGEPORT
Paradise
Balsora
Boonsville
Cottondale
Stony
Ponder
Corinth
Hickory Creek
Argyle
Highland Village
Bartonville
Aurora
Rhome
Newark
Avondale
Navo
Rockhill
Fairview
Forest Grove
Lucas
Murphy
Hebron
Sachse
GARZA LITTLE ELM RESERVOIR
LAVON RESERVOIR
PROPOSED ROANOKE RESERVOIR
GRAPEVINE RESERVOIR
Poolville
Peden
Dido
EAGLE MT. LAKE
Haslet
Westlake
Robertson
Keller
Lakeview
Smithfield
Colleyville
North Richland Hills
Authon
Peaster
Lakeside
LAKE WEATHERFORD
Willow Park
LAKE WORTH
Irving
Grand Prairie
BACHMAN LAKE
WHITE ROCK LAKE
LAKE RAY HUBBARD
NORTH LAKE
Luthers
Benbrook
BENBROOK RESERVOIR
Forrest Hill
LAKE ARLINGTON
MT. CREEK LAKE
Duncanville
Webb
Lancaster
De Soto
PROPOSED LAKEVIEW RESERVOIR
Watsonville
Bisbee
Rendon
Brock
Dennis
Cresson
DE CORDOVA BEND RESERVOIR
Lillian
Egan
Red Oak
Ovilla
Ferris
India
Trumbull
Sterret
Rocket
Sardis
Ike
Boyce
Garrett
Crisp
Telico
Reagor Springs
Nena
LAKE WAXAHACHIE
Howard
BARDWELL RESERVOIR
Bardwell
Alma
Nash
Boz
Avalon
Rankin
LAKE ALVARADO
LAKE PAT CLEBURNE
Parker
Rio Vista
Scale In Miles
4 0 4 8 12
N



North Central Texas Council Of Governments

UPPER TRINITY RIVER BASIN
COMPREHENSIVE SEWERAGE PLAN

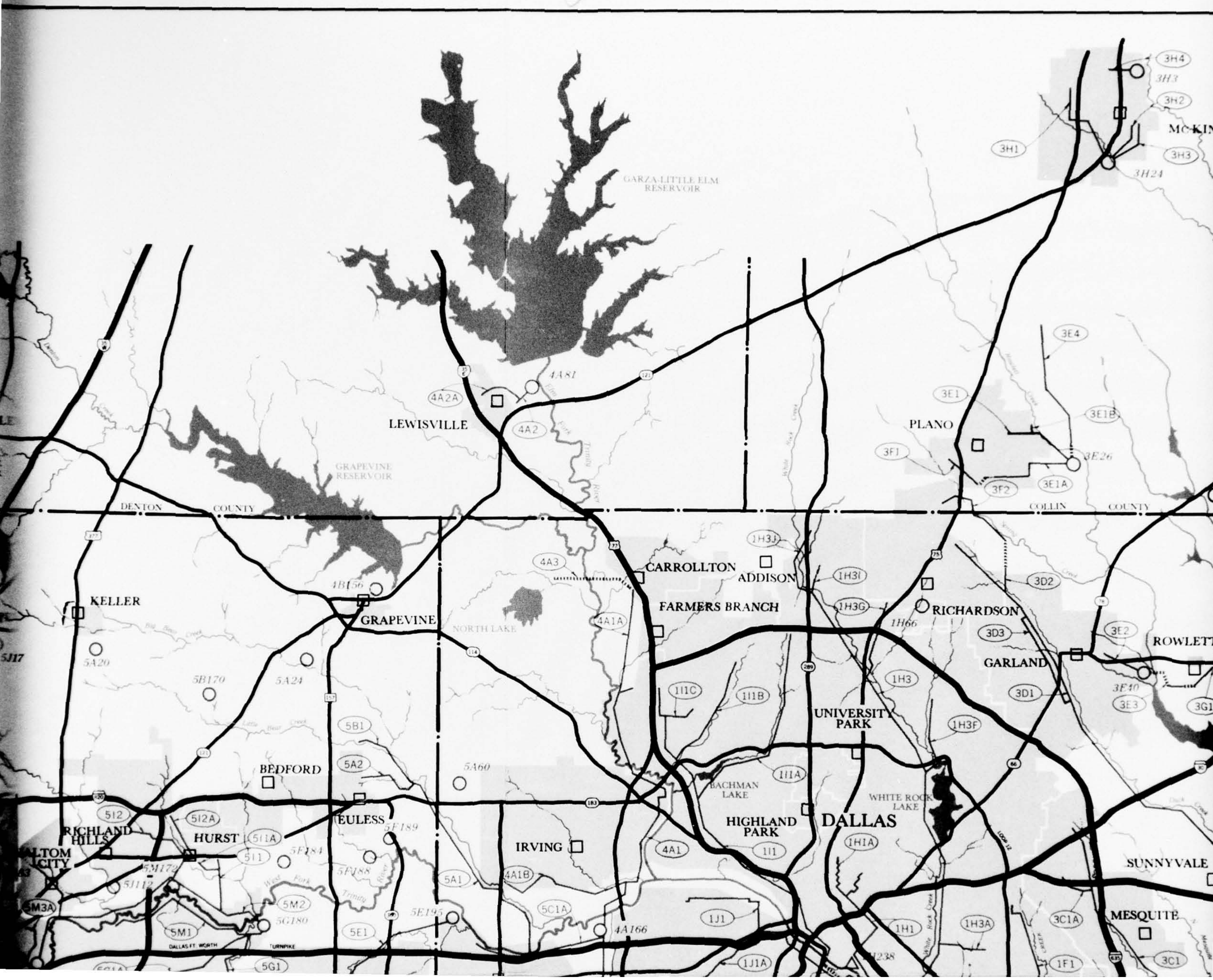
SOILS AND SEPTIC TANK CONCENTRATIONS

CAMP, DRESSER AND MC KEE General Consultants
FORREST AND COTTON, INC. Associate Consultants
FREESE, NICHOLS AND ENDRESS Associate Consultants

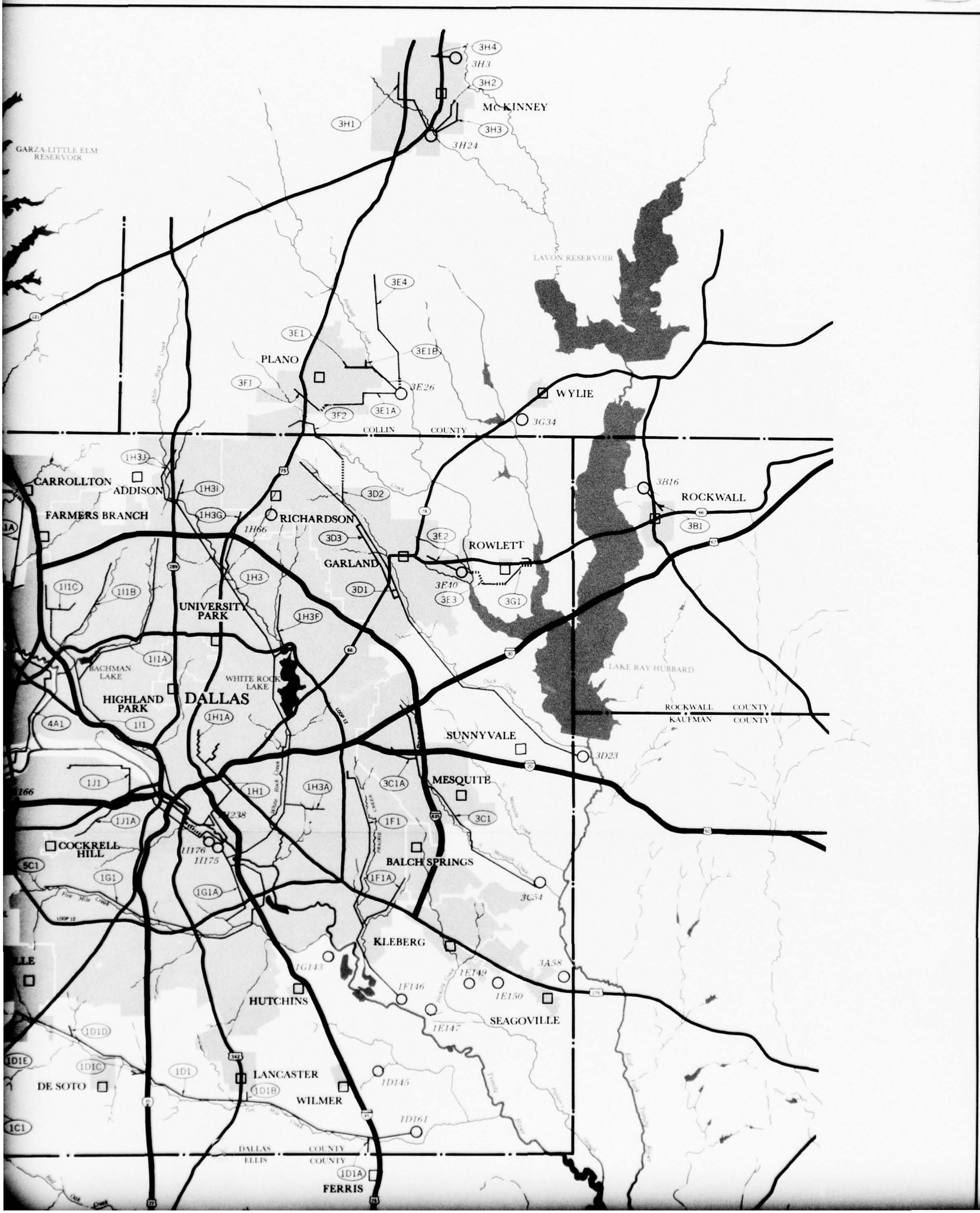
JULY 1970 | FIG. IV-3

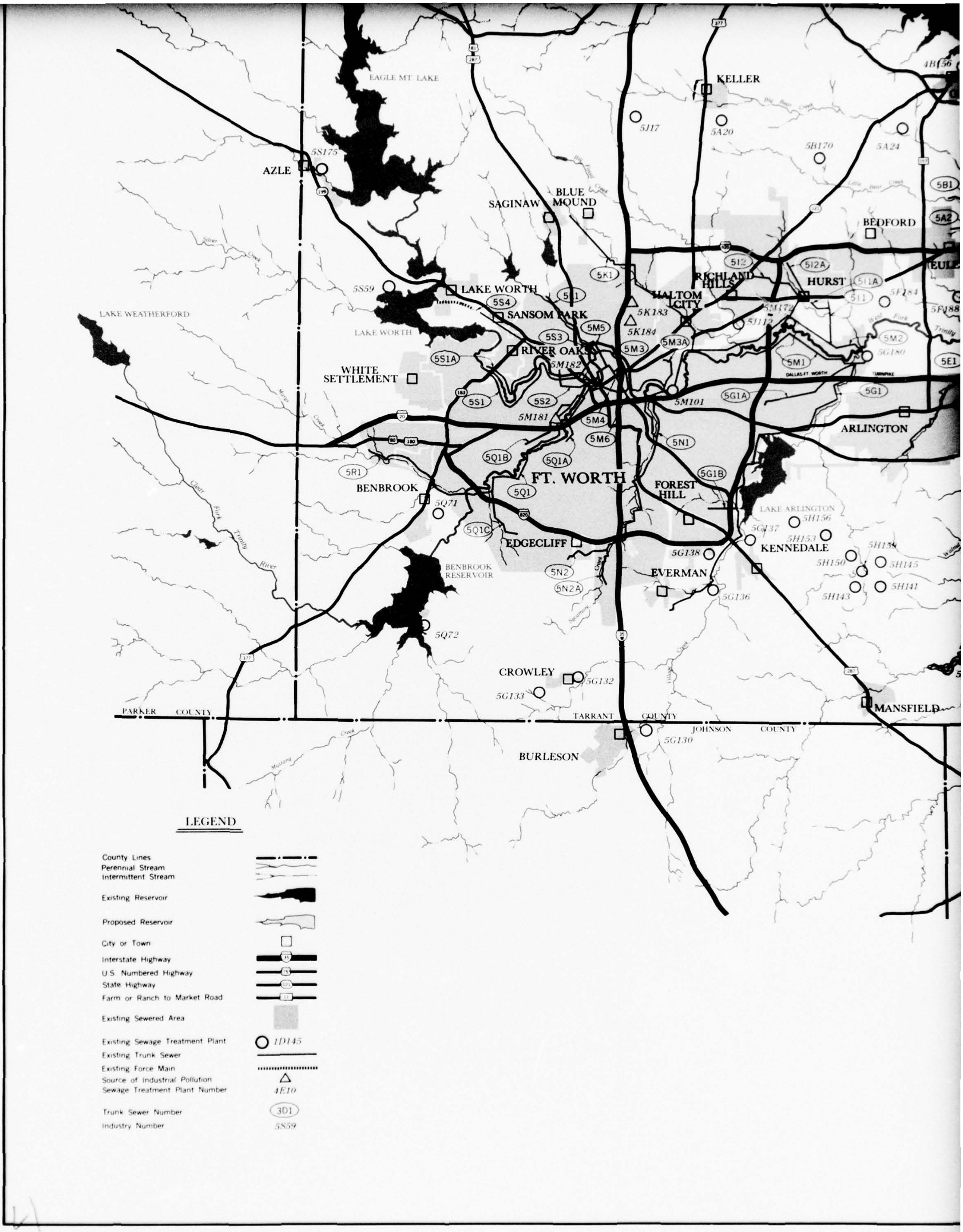
6

WISE
COUNTY
DENTON
COUNTY
GRAPEV
RESERV
EAGLE MT. LAKE
KELLER
5J17
5A20
5B170
5A24
4B156
AZLE
5S175
SAGINAW
BLUE MOUND
BEDFORD
5B1
5A2
LAKE WEATHERFORD
5S59
LAKE WORTH
5S4
SANSOM PARK
LAKE WORTH
RICHLAND HILLS
HALTOM CITY
HURST
5I2
5I2A
5I1A
5I1
5K1
5K183
5K184
5M172
5J112
5M5
5S3
5M3
5M3A
5M2
5G180
5M1
5E1
RIVER OAKS
5M182
5S1A
WHITE SETTLEMENT
5S1
5S2
5M181
5M101
5G1A
5G1
DALLAS-FT. WORTH TURNPIKE
ARLINGTON
5M4
5M6
5N1
5R1
5Q1B
5Q1A
FT. WORTH
5G1B
BENBROOK
5Q71
5Q1
FOREST HILL
LAKE ARLINGTON
5H156
5G137
5H153
5Q1C
EDGECLIFF
5G138
KENNEDALE
5H150
5H145
5H141
5H143
BENBROOK RESERVOIR
5N2
5N2A
EVERMAN
5G136
5Q72
CROWLEY
5G132
5G133
MANSFIELD
PARKER
COUNTY
TARRANT
COUNTY
JOHNSON
COUNTY
5G130
BURLESON
West Fork Trinity River
Clear Fork Trinity River
Big Bear Creek
Silver Creek



GARZA-LITTLE ELM RESERVOIR
GRAPEVINE RESERVOIR
NORTH LAKE
BACHMAN LAKE
WHITE ROCK LAKE
DENTON COUNTY
COLLIN COUNTY
LEWISVILLE
PLANO
McKIN
CARROLLTON
ADDISON
FARMERS BRANCH
RICHARDSON
ROWLETT
GARLAND
KELLER
GRAPEVINE
UNIVERSITY PARK
BEDFORD
EULESS
HURST
RICHLAND HILLS
HALTOM CITY
IRVING
HIGHLAND PARK
DALLAS
SUNNYVALE
MESQUITE
DALLAS FT. WORTH TURNPIKE
3H4
3H3
3H2
3H1
3H24
3E4
3E1
3E1B
3E26
3F1
3F2
3E1A
4A81
4A2A
4A2
1H3J
1H3I
1H3G
1H66
3D2
3D3
3E2
3D1
3E10
3E3
3G1
4A3
4B156
4A1A
5A20
5B170
5A24
1I1C
1I1B
1H3
1H3F
5B1
5A2
5A60
1I1A
5I2
5I2A
5I1A
5I1
5F189
5F184
5F188
4A1
1I1
1H1A
5M172
5J112
5M3A
5M2
5G180
5M1
5A1
4A1B
5C1A
5E195
4A166
1J1
1H1
1H3A
3C1A
5E1
5G1
1J1A
1F1
3C1

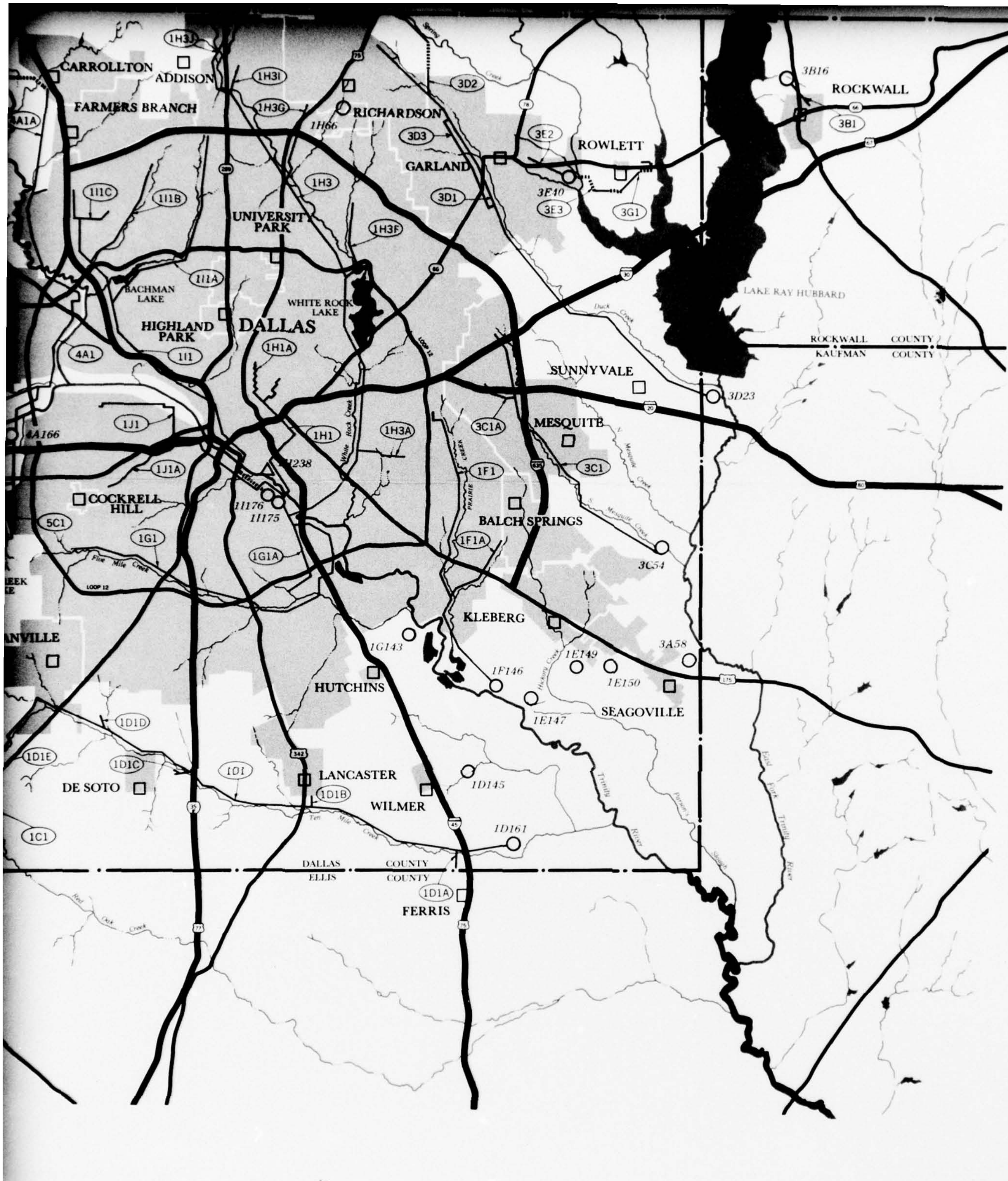

3
McKINNEY
GARZA-LITTLE ELM RESERVOIR
LAVON RESERVOIR
PLANO
WYLIE
COLLIN COUNTY
CARROLLTON
ADDISON
FARMERS BRANCH
RICHARDSON
ROCKWALL
ROWLETT
GARLAND
UNIVERSITY PARK
BACHMAN LAKE
WHITE ROCK LAKE
HIGHLAND PARK
DALLAS
LAKE RAY HUBBARD
ROCKWALL COUNTY
KAUFMAN COUNTY
SUNNYVALE
MESQUITE
COCKRELL HILL
BALCH SPRINGS
KLEBERG
HUTCHINS
SEAGOVILLE
LANCASTER
DE SOTO
WILMER
DALLAS COUNTY
ELLIS COUNTY
FERRIS



EAGLE MT. LAKE
KELLER
AZLE
5S175
5J17
5A20
5B170
5A24
4B156
SAGINAW
BLUE MOUND
BEDFORD
5B1
5A2
5I2
5I2A
RICHLAND HILLS
HURST
5I1A
5I1
EULE
5K1
HALTOM CITY
5F184
5F188
5S59
LAKE WORTH
5S4
SANSOM PARK
5K183
5K184
5M172
5J112
LAKE WEATHERFORD
LAKE WORTH
5S3
5M5
5M3
5M3A
5M2
5G180
RIVER OAKS
5S1A
5M182
5M1
5E1
WHITE SETTLEMENT
DALLAS-FT. WORTH TURNPIKE
5S1
5S2
5M101
5G1A
5G1
5M181
5M4
ARLINGTON
5M6
5N1
5R1
5Q1B
5Q1A
FT. WORTH
5G1B
BENBROOK
5Q1
FOREST HILL
5Q71
LAKE ARLINGTON
5H156
5Q1C
5G137
5H153
EDGECLIFF
KENNEDALE
5H139
5G138
5H150
5H145
BENBROOK RESERVOIR
5N2
EVERMAN
5N2A
5H143
5H141
5G136
Trinity River
Clear Fork
Silver Creek
5Q72
CROWLEY
5G132
5G133
MANSFIELD
PARKER COUNTY
TARRANT COUNTY
JOHNSON COUNTY
5G130
BURLESON
LEGEND
County Lines
Perennial Stream
Intermittent Stream
Existing Reservoir
Proposed Reservoir
City or Town
Interstate Highway
U.S. Numbered Highway
State Highway
Farm or Ranch to Market Road
Existing Sewered Area
Existing Sewage Treatment Plant
1D145
Existing Trunk Sewer
Existing Force Main
Source of Industrial Pollution
Sewage Treatment Plant Number
4E10
Trunk Sewer Number
3D1
Industry Number
5S59

ARLINGTON
GRAND PRAIRIE
COCKRELL HILL
MESQUITE
BALCH SPRINGS
FOREST HILL
LAKE ARLINGTON
KENNEDALE
EVERMAN
MT. CREEK LAKE
DUNCANVILLE
KLEBERG
HUTCHINS
LAKEVIEW RESERVOIR (FUTURE)
CEDAR HILL
DE SOTO
LANCASTER
WILMER
MANSFIELD
FERRIS
JOHNSON COUNTY
DALLAS COUNTY
ELLIS COUNTY
5M3A
5M1
5M2
5G180
5E1
5E195
5C1A
4A166
1J1
1H1
1H3A
3C1A
3C1
1F1
1J1A
1H238
5G1A
5G1
5M101
5N1
5G1B
5C1
1G1
1I176
1I175
1G1A
1F1A
5C1B
5C1B1
5H156
5G137
5H153
5H159
5H150
5H145
5H141
5H143
5G138
5G136
1G143
1F146
1E149
1E147
1D1D
1D1E
1D1C
1D1
1D1B
1D145
1D161
5D214
1C1
1D1A
5G130
LOOP 12
DALLAS-FT. WORTH TURNPIKE
Five Mile Creek
Ten Mile Creek
Red Oak Creek
Walnut Creek
Mountain Creek
West Fork Trinity River
N
Scale In Miles

5

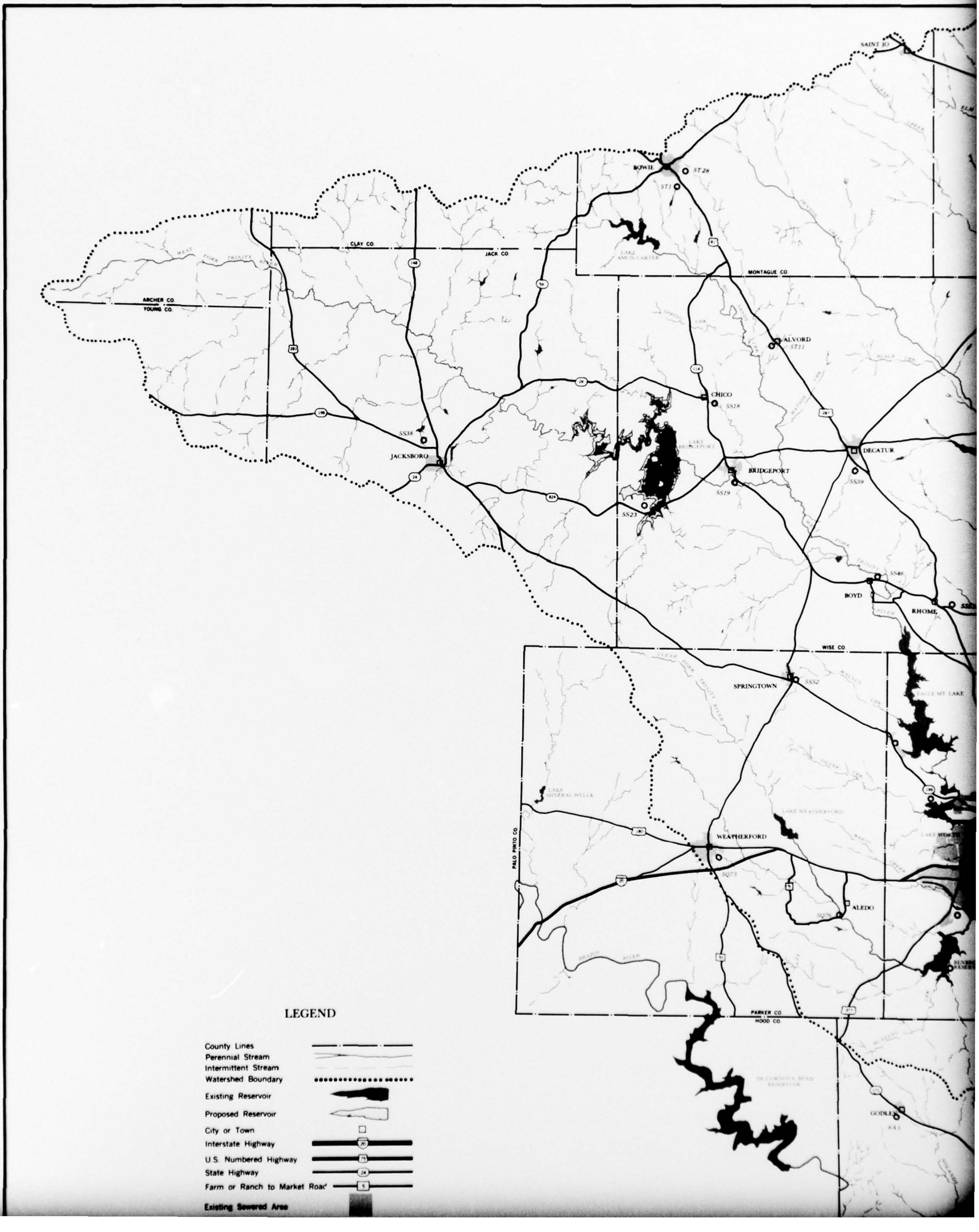


North Central Texas Council Of Governments
UPPER TRINITY RIVER BASIN
COMPREHENSIVE SEWERAGE PLAN

EXISTING SANITARY SEWERAGE FACILITIES - 2

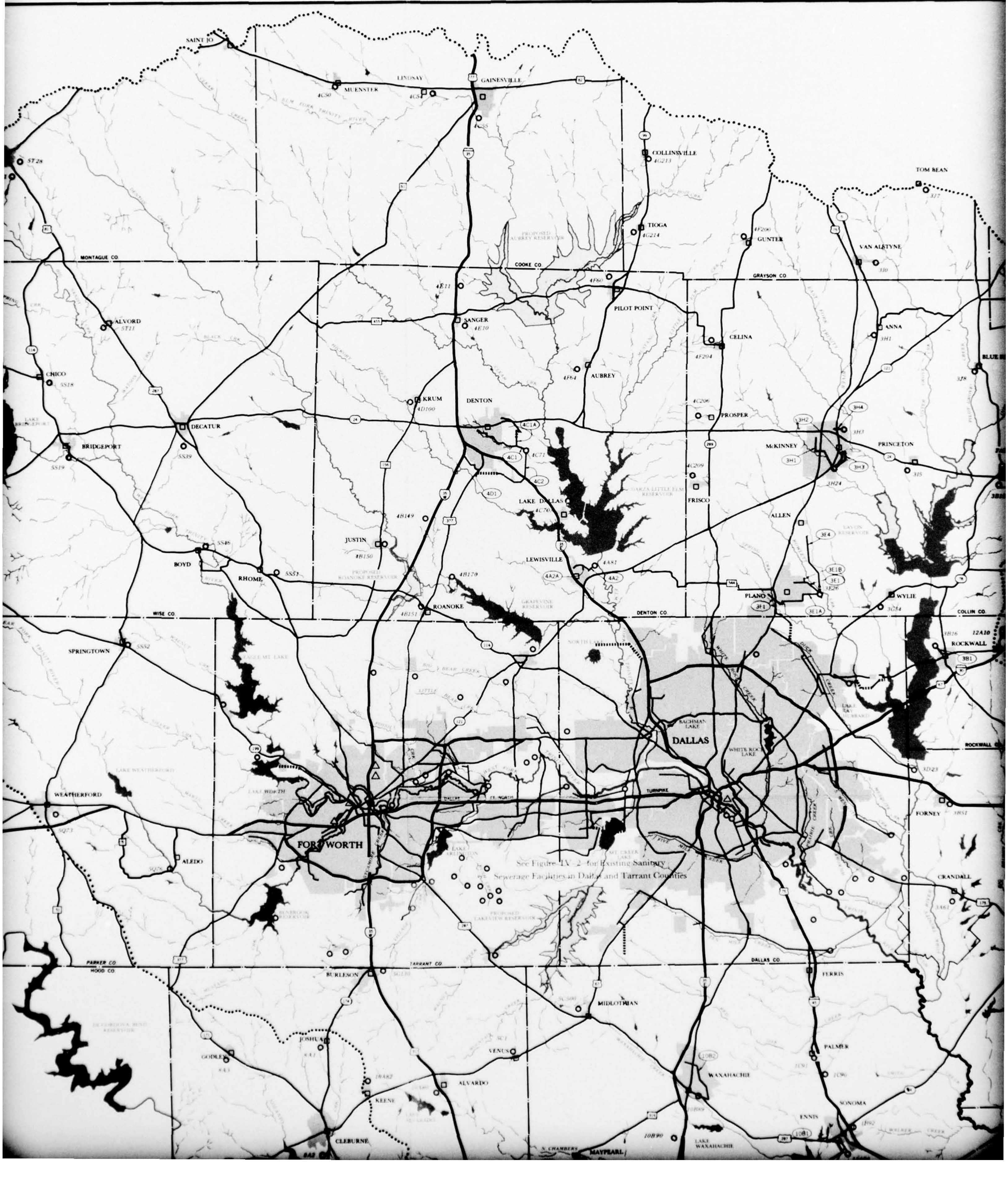
CAMP, DRESSER AND MC KEE General Consultants
FORREST AND COTTON, INC. Associate Consultants
FREESE, NICHOLS AND ENDRESS Associate Consultants

JULY 1970 | FIG. IV-2



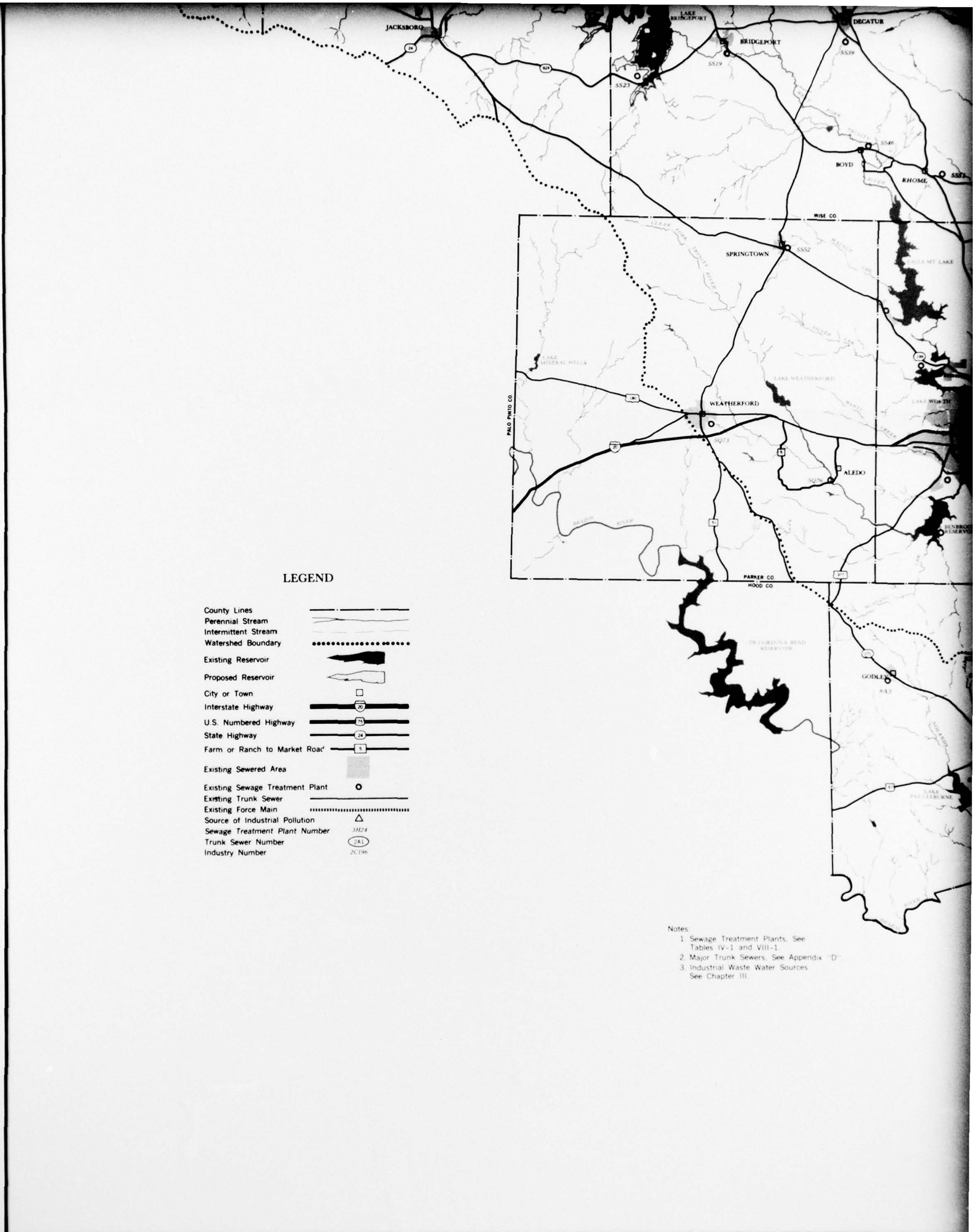
SAINT JO
BOWIE
ST28
ST1
LAKE AMON CARTER
CLAY CO.
JACK CO.
MONTAGUE CO.
ARCHER CO.
YOUNG CO.
WEST FORK TRINITY RIVER
ALVORD
ST11
CHICO
SS18
LAKE BRIDGEPORT
DECATUR
SS39
BRIDGEPORT
SS19
SS38
JACKSBORO
SS23
SS46
BOYD
RHOME
WISE CO.
CLEAR FORK TRINITY RIVER
SPRINGTOWN
SS52
EAGLE MT LAKE
LAKE MINERAL WELLS
LAKE WEATHERFORD
LAKE WORTH
WEATHERFORD
SQ73
PALO PINTO CO.
ALEDO
SQ76
BRAZOS RIVER
PARKER CO.
HOOD CO.
DE CORDOVA BEND RESERVOIR
GODLEY
LEGEND
County Lines
Perennial Stream
Intermittent Stream
Watershed Boundary
Existing Reservoir
Proposed Reservoir
City or Town
Interstate Highway
U.S. Numbered Highway
State Highway
Farm or Ranch to Market Road
Existing Sewered Area

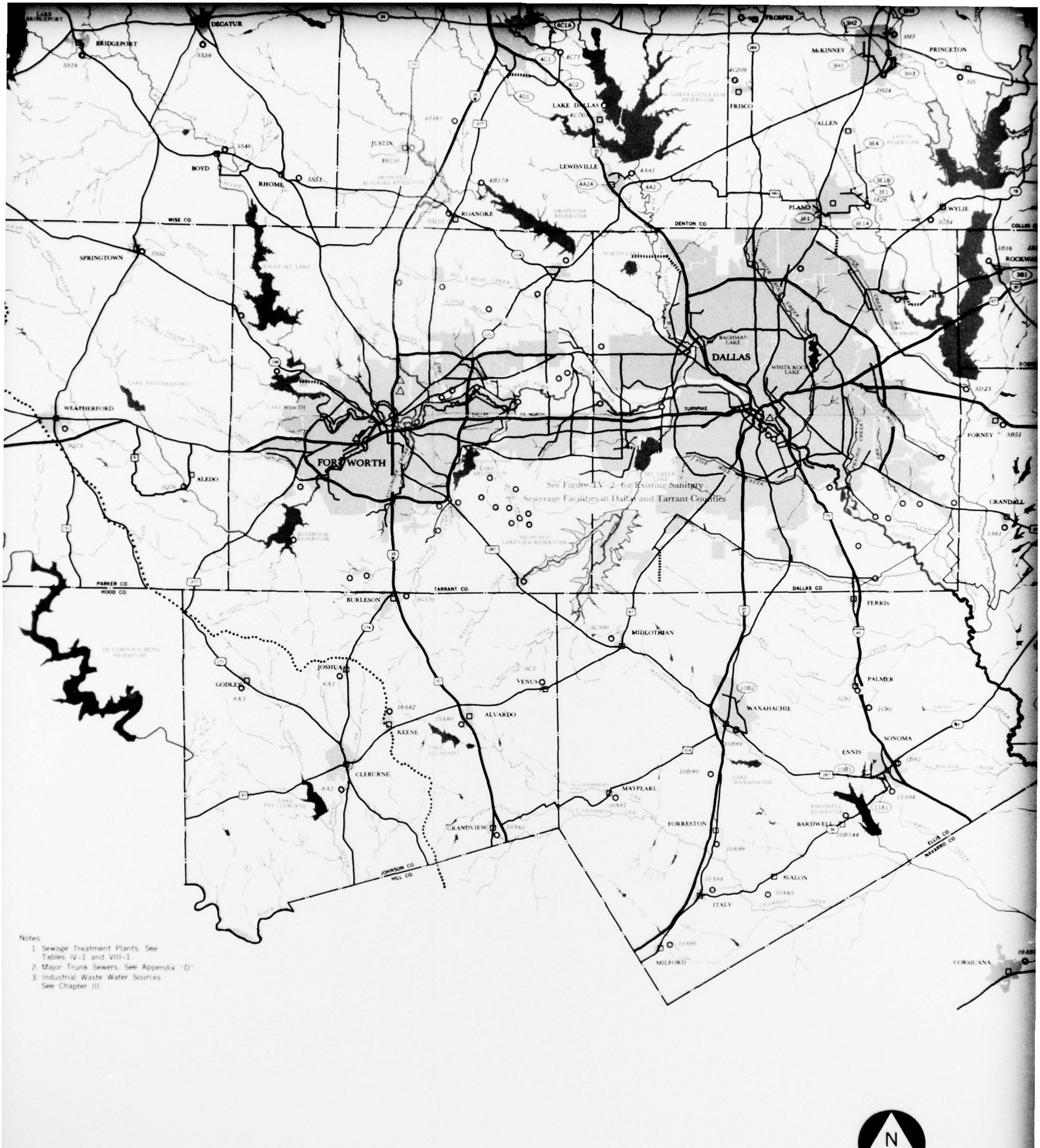
2



SAINT JO
MUENSTER
4C50
LINDSAY
4C54
GAINESVILLE
4C55
COLLINSVILLE
4G213
TIOGA
4G214
GUNTER
4F200
TOM BEAN
3I7
VAN ALSTYNE
3I0
PROPOSED AUBREY RESERVOIR
MONTAGUE CO.
COOKE CO.
GRAYSON CO.
4E11
4F60
PILOT POINT
SANGER
4E10
ALVORD
ST11
CELINA
4F204
ANNA
3H1
AUBREY
4F64
CHICO
SS18
KRUM
4D100
DENTON
LAKE BRIDGEPORT
DECATUR
SS39
BRIDGEPORT
SS19
4C1A
4C1
4C71
4C2
4D1
4C206
PROSPER
3H2
3H4
3H3
McKINNEY
PRINCETON
4C209
FRISCO
3H1
3H24
3I5
GARZA LITTLE ELM RESERVOIR
LAKE DALLAS
4C70
4B149
ALLEN
LAVON RESERVOIR
JUSTIN
4B150
SS46
BOYD
RHOME
SS51
PROPOSED ROANOKE RESERVOIR
LEWISVILLE
4A81
4A2A
4A2
3E4
3E1B
3E1
3E26
4B170
GRAPEVINE RESERVOIR
PLANO
3F1
3E1A
WYLIE
3G34
WISE CO.
4B151
ROANOKE
DENTON CO.
COLLIN CO.
3B16
12A10
ROCKWALL
3B1
SPRINGTOWN
SS52
EAGLE MT. LAKE
NORTH LAKE
BIG BEAR CREEK
BACHMAN LAKE
DALLAS
WHITE ROCK LAKE
LAKE RAY HUBBARD
ROCKWALL CO.
LAKE WEATHERFORD
LAKE WORTH
3D23
WEATHERFORD
TURNPIKE
FORNEY
3BS1
SQ73
FORT WORTH
LAKE ARLINGTON
MT. CREEK LAKE
SQ76
ALEDO
See Figure IV-2 for Existing Sanitary Sewerage Facilities in Dallas and Tarrant Counties
CRANDALL
3A61
BENBROOK RESERVOIR
PROPOSED LAKEVIEW RESERVOIR
PARKER CO.
HOOD CO.
TARRANT CO.
DALLAS CO.
BURLESON
FERRIS
MIDLOTHIAN
DE CORDOVA BEND RESERVOIR
JOSHUA
VENUS
GODLEY
10B2
PALMER
WAXAHACHIE
ALVARDO
KEENE
ENNIS
SONOMA
10B1
CLEBURNE
N. CHAMBERS
MAYPEARL
LAKE WAXAHACHIE


TOM BEAN
TRENTON
LEONARD
Watershed Boundary
COLLINSVILLE
TIOGA
GUNTER
VAN ALSTYNE
PILOT POINT
CELINA
ANNA
BLUE RIDGE
AUBREY
PROSPER
McKINNEY
PRINCETON
FARMERSVILLE
FRISCO
LAKE DALLAS
ALLEN
JOSEPHINE
LEWISVILLE
PLANO
WYLIE
ROYSE CITY
ROCKWALL
FATE
DALLAS
FORNEY
TERRELL
WILLS POINT
CRANDALL
KAUFMAN
FERRIS
MIDLOTHIAN
PALMER
WAXAHACHIE
KEMP
ENNIS
SONOMA
MABANK
MAYPEARL
COOKE CO.
GRAYSON CO.
FANNIN CO.
HUNT CO.
DENTON CO.
COLLIN CO.
ROCKWALL CO.
DALLAS CO.
KAUFMAN CO.
VAN ZANDT CO.
See Figure IV-2 for Existing Sanitary Sewerage Facilities in Dallas and Tarrant Counties
Watershed Boundary
KEY MAP OF STUDY AREA

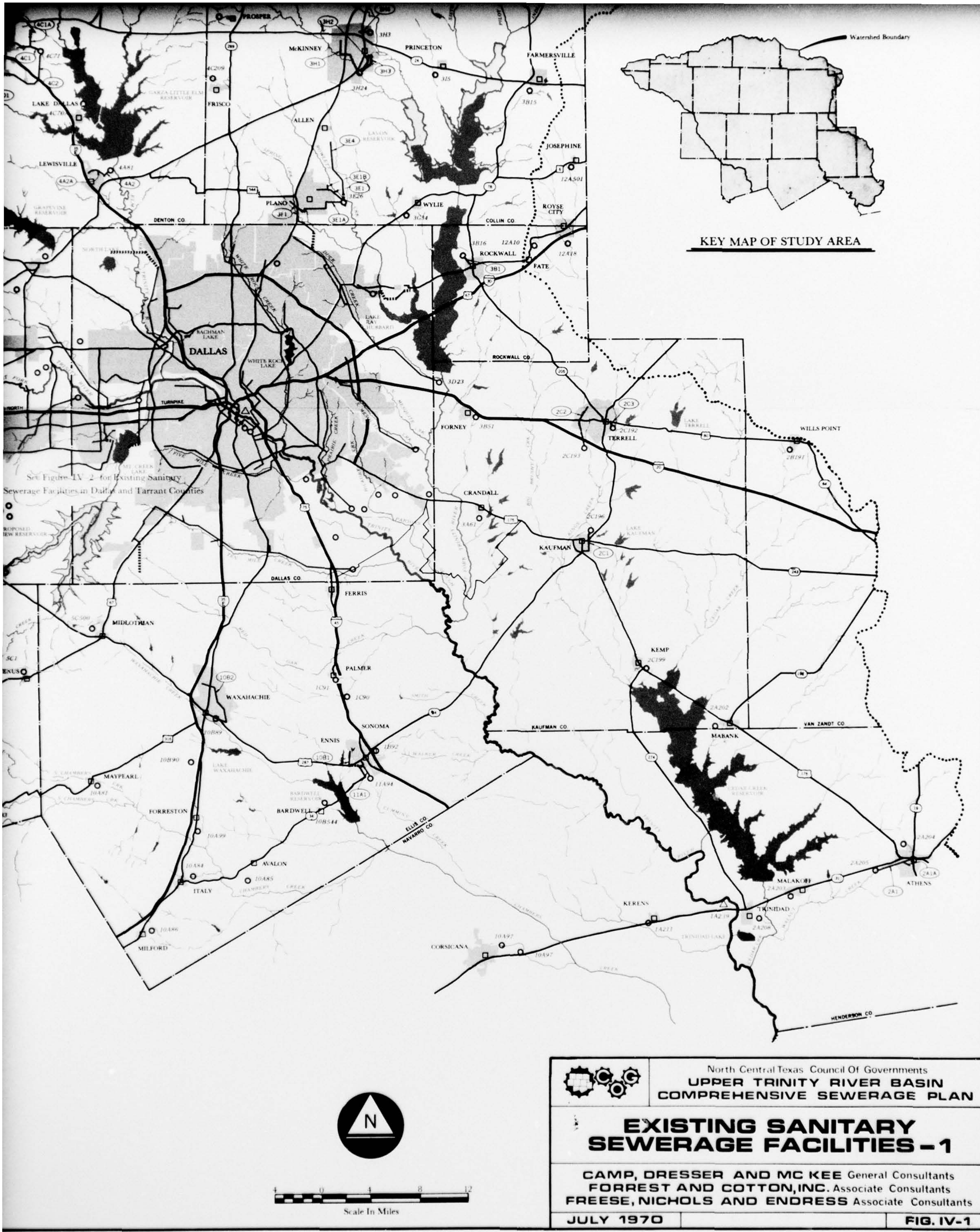

JACKSBORO
LAKE BRIDGEPORT
BRIDGEPORT
DECATUR
SS39
SS19
SS23
SS46
BOYD
RHOME
WISE CO
SPRINGTOWN
SS52
EAGLE MT LAKE
LAKE MINERAL WELLS
LAKE WEATHERFORD
WEATHERFORD
SQ73
ALEDO
PALO PINTO CO
BRAZOS RIVER
PARKER CO
HOOD CO
BENBROOK RESERVOIR
DE CORDOVA BEND RESERVOIR
GODLEY
LAKE PAT CLEBURNE
LEGEND
County Lines
Perennial Stream
Intermittent Stream
Watershed Boundary
Existing Reservoir
Proposed Reservoir
City or Town
Interstate Highway
U.S. Numbered Highway
State Highway
Farm or Ranch to Market Road
Existing Sewered Area
Existing Sewage Treatment Plant
Existing Trunk Sewer
Existing Force Main
Source of Industrial Pollution
Sewage Treatment Plant Number
3H24
Trunk Sewer Number
2A1
Industry Number
2C196
Notes
1. Sewage Treatment Plants, See Tables IV-1 and VIII-1.
2. Major Trunk Sewers, See Appendix "D".
3. Industrial Waste Water Sources See Chapter III.



Notes:
1. Sewage Treatment Plants, See Tables IV-1 and VIII-1.
2. Major Trunk Sewers, See Appendix "D".
3. Industrial Waste Water Sources See Chapter III.

4 0 4 8 12

Scale In Miles



North Central Texas Council Of Governments

UPPER TRINITY RIVER BASIN COMPREHENSIVE SEWERAGE PLAN

EXISTING SANITARY SEWERAGE FACILITIES – 1

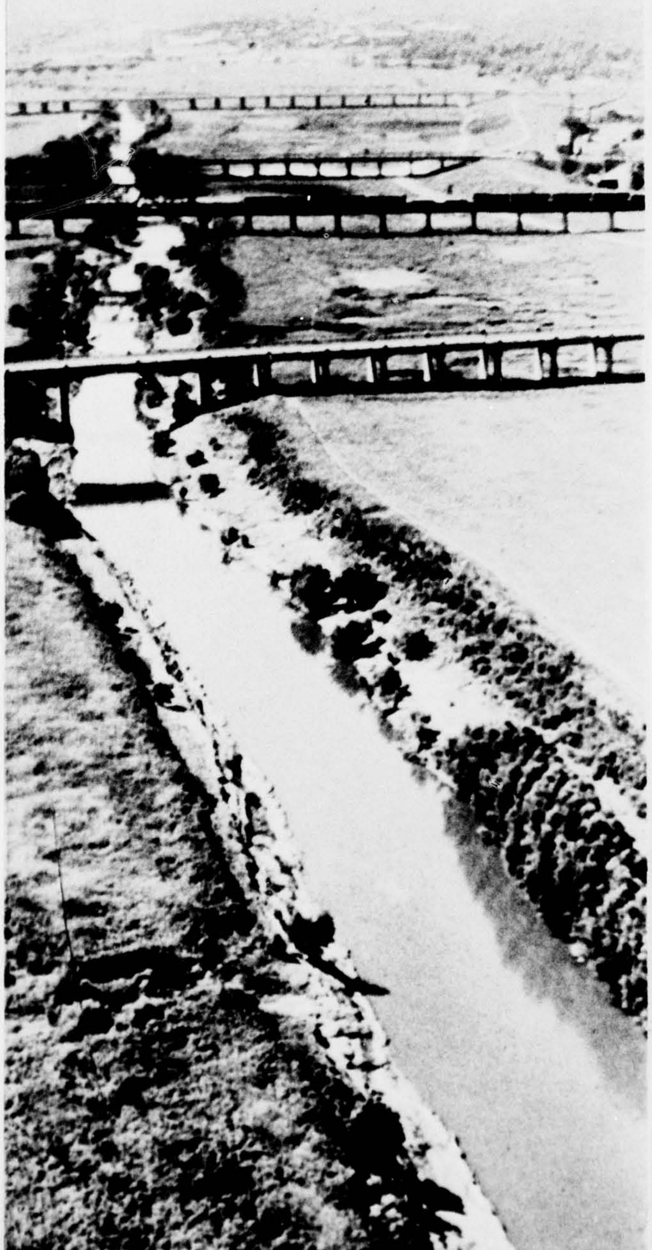
CAMP, DRESSER AND MC KEE General Consultants
FORREST AND COTTON, INC. Associate Consultants
FREESE, NICHOLS AND ENDRESS Associate Consultants

JULY 1970

FIG. IV-1

UPPER TRINITY RIVER BASIN COMPREHENSIVE SEWERAGE PLAN

north central texas council of governments



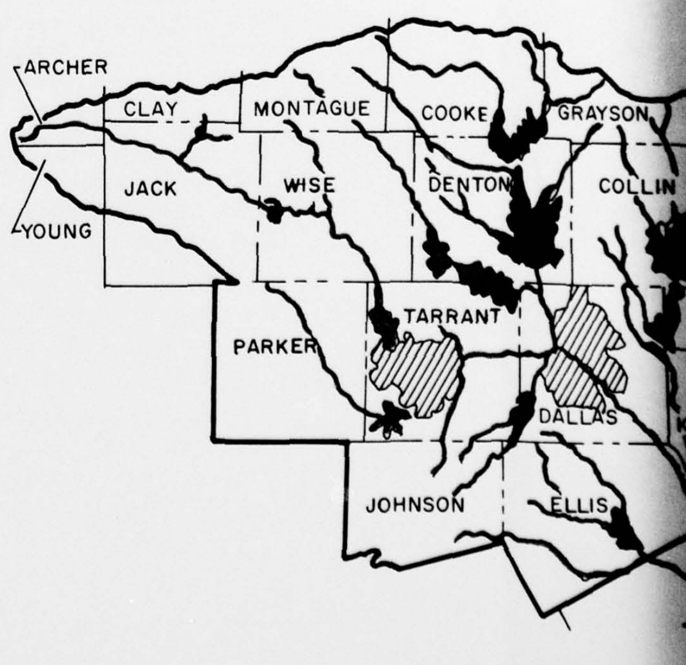
The North Central Texas Council of Governments (NCTCOG) sponsored a study which resulted in a Comprehensive Sewerage Plan for the Upper Trinity River Basin which proposes some consolidation of sewerage systems for treatment and disposal facilities.

Development of a proposal for joint sewerage facilities illustrates the regional planning function of the North Central Texas Council of Governments. This voluntary association of 127 member governments provides a forum for resolving area wide problems. NCTCOG also promotes intergovernmental cooperation and coordination.

Under
the inte
financed
Quality
Protectio

NCTC
& McKe
gineering
rest and
Freese,
Worth.

Their
sulted i
evaluatin
projected
the Nor
contains
dations
water p



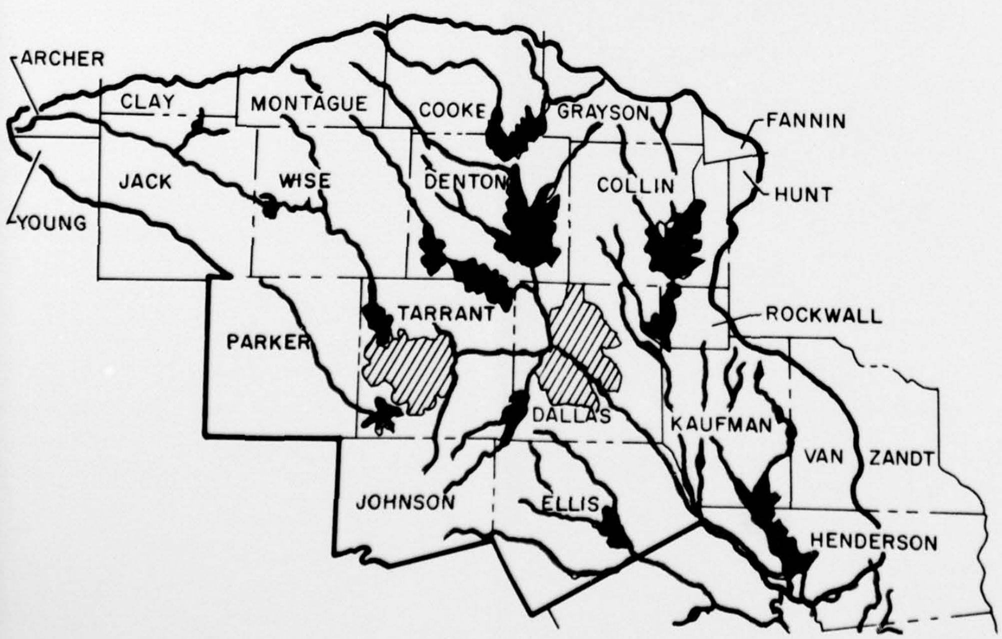
The North Central Texas Council of Governments (NCTCOG) sponsored a study which resulted in a Comprehensive Sewerage Plan for the Upper Trinity River Basin which proposes some consolidation of sewerage systems for treatment and disposal facilities.

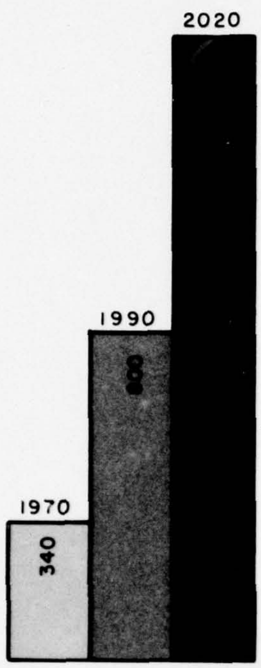
Development of a proposal for joint sewerage facilities illustrates the regional planning function of the North Central Texas Council of Governments. This voluntary association of 127 member governments provides a forum for resolving area wide problems. NCTCOG also promotes intergovernmental cooperation and coordination.

Under the direction of NCTCOG, the intensive 18-month project was financed jointly by the Texas Water Quality Board and the Environmental Protection Agency.

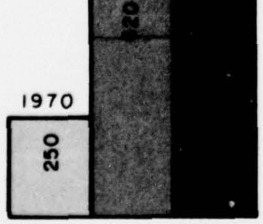
NCTCOG selected Camp, Dresser & McKee of Boston to head the engineering team which included Forrest and Cotton Inc. of Dallas, and Freese, Nichols and Endress of Fort Worth.

Their research and analysis resulted in a two-volume presentation evaluating in detail the existing and projected water pollution problems of the North Central Texas region. It contains future planning recommendations and provides guidelines for water pollution control facilities.

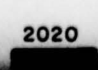




ESTIMATED
WATER CONSUMPTION
(MGD)



ESTIMATED
SEWAGE
FLOW
(MGD)



Within the 11,000 square miles covered by the Upper Trinity River Basin study, 11 NCTCOG member counties are located—Dallas, Tarrant, Ellis, Denton, Hunt, Johnson, Collin, Kaufman, Parker, Rockwall, and Wise. Portions of 10 other counties fall within the study boundaries.

Natural water resources exist in sufficient quantity to adequately supply the area's needs for the next 20 years.

However, the quality of the water provided by the Upper Trinity River and its tributaries poses an increasingly serious problem.

In dry parts of the year, the flow consists primarily of the discharge from approximately 132 sewage treatment plants. Septic tank discharges, raw sewage from many homes, industrial wastewater, leaching of dumps and landfills, and surface runoff in both urban and rural areas add to the heavy pollution load.

Twenty percent of the state's population resides within the geographical limits of the Upper Trinity River Basin.

The study indicates that by the year 2020 the metropolitan area of Dallas-Fort Worth will have 6.4 million residents. The combined urban and rural population will grow to over 7.8 million people.

They will consume approximately 1,509 million gallons of water per day. Sewage flow in 2020 will reach an estimated 1,130 million gallons per day.

All
point
deman
proble

Thr
ysis, t
the ca
sewag
age so
tions.

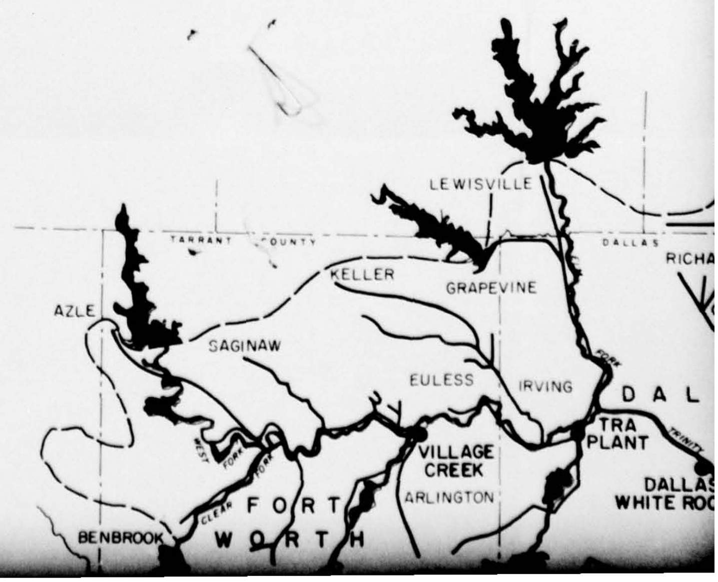
In t
the c
limite
numb
scatte
tan ar

Urb
consol
the fo

1. D
2. D
3. T
4. T
M
5. R
6. F

Rur
separa
day,
would

Upg
treatm
qualit
efficie



Within the 11,000 square miles covered by the Upper Trinity River Basin study, 11 NCTCOG member counties are located—Dallas, Tarrant, Ellis, Denton, Hunt, Johnson, Collin, Kaufman, Parker, Rockwall, and Wise. Portions of 10 other counties fall within the study boundaries.

Natural water resources exist in sufficient quantity to adequately supply the area's needs for the next 20 years.

However, the quality of the water provided by the Upper Trinity River and its tributaries poses an increasingly serious problem.

In dry parts of the year, the flow consists primarily of the discharge from approximately 132 sewage treatment plants. Septic tank discharges, raw sewage from many homes, industrial wastewater, leaching of dumps and landfills, and surface runoff in both urban and rural areas add to the heavy pollution load.

Twenty percent of the state's population resides within the geographical limits of the Upper Trinity River Basin.

The study indicates that by the year 2020 the metropolitan area of Dallas-Fort Worth will have 6.4 million residents. The combined urban and rural population will grow to over 7.8 million people.

They will consume approximately 1,509 million gallons of water per day. Sewage flow in 2020 will reach an estimated 1,130 million gallons per day.

All growth projections for the area point to greater water and sewage demands and increased pollution problems.

Through extensive computer analysis, the engineering team evaluated the capacity and adequacy of existing sewage plants and the region's sewage sources in relation to plant locations.

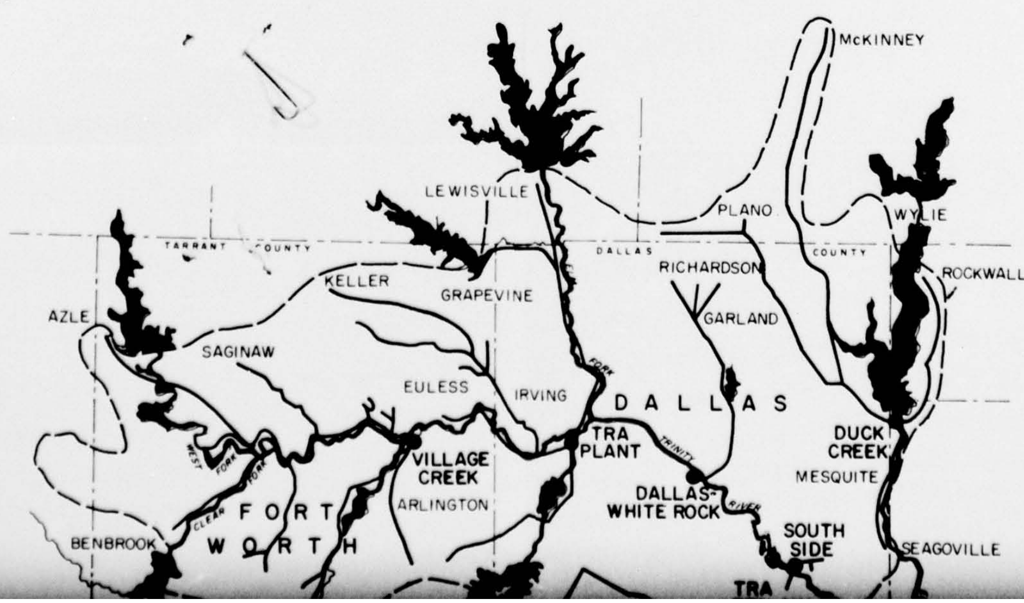
In terms of efficiency and economy, the consultant team recommended limited consolidation of the large number of sewage treatment plants scattered throughout the metropolitan areas into six joint systems.

Urban areas would be served by consolidated facilities associated with the following existing plants:

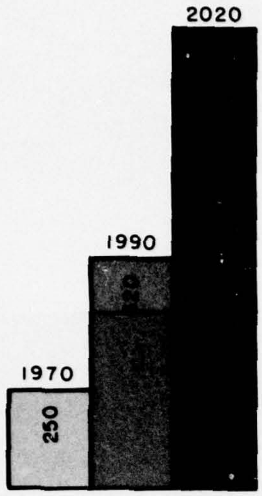
1. Dallas White Rock
2. Dallas South Side
3. Trinity River Authority Central
4. Trinity River Authority Ten Mile Creek
5. Richardson-Garland Duck Creek
6. Fort Worth Village Creek

Rural communities would operate separate plants, much as they do today, since joint plant construction would not be economically feasible.

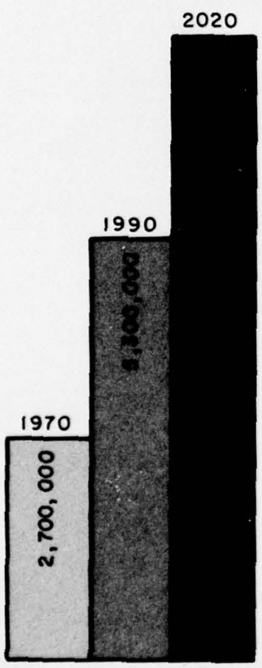
Upgrading of the present sewage treatment facilities to increase the quality of the effluent would insure efficient pollution control.



ESTIMATED
WATER CONSUMPTION
(MGD)



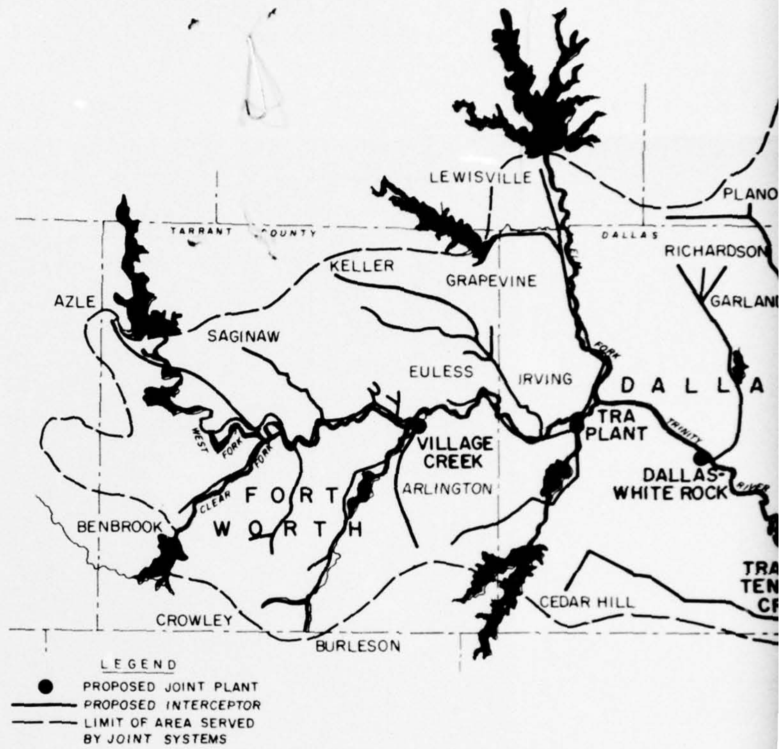
ESTIMATED
SEWAGE
FLOW
(MGD)



TOTAL
ESTIMATED
POPULATION

The study indicates that by the year 2020 the metropolitan area of Dallas-Fort Worth *will have 6.4 million residents.* The combined urban and rural population will grow to *over 7.8 million people.*

They will consume approximately 1,509 million gallons of water per day. Sewage flow in 2020 will reach an estimated 1,130 million gallons per day.



RECOMMENDED REGIONAL SEWERAGE SYS

The report recommends phasing out 47 metropolitan area plants. The remaining six joint plants would be expanded to produce high quality effluent. By 1990, combined facilities would handle 92% of the sewage in the study area.

Residents of the North Central Region cannot expect the pollution problem to solve itself. Communities must take preventive action to retard the spread of pollution throughout their lakes, rivers and streams and into their water supplies. Although the study presents a comprehensive 50-year pollution and water quality control plan, its benefits would be realized immediately.

With the addition of possible state and federal money, construction costs assumed by the individual may decrease to less than the 20¢ per day per family.

separate pl
day, since
would not l

Upgradin
treatment f
quality of t
efficient po

The Com
for the Up
helps comr
vital and in

1. Conso
ment facil
economical
water in N

2. The s
method of
pollution t
for the nex

A worka
tion of the
Plan needs
nation and

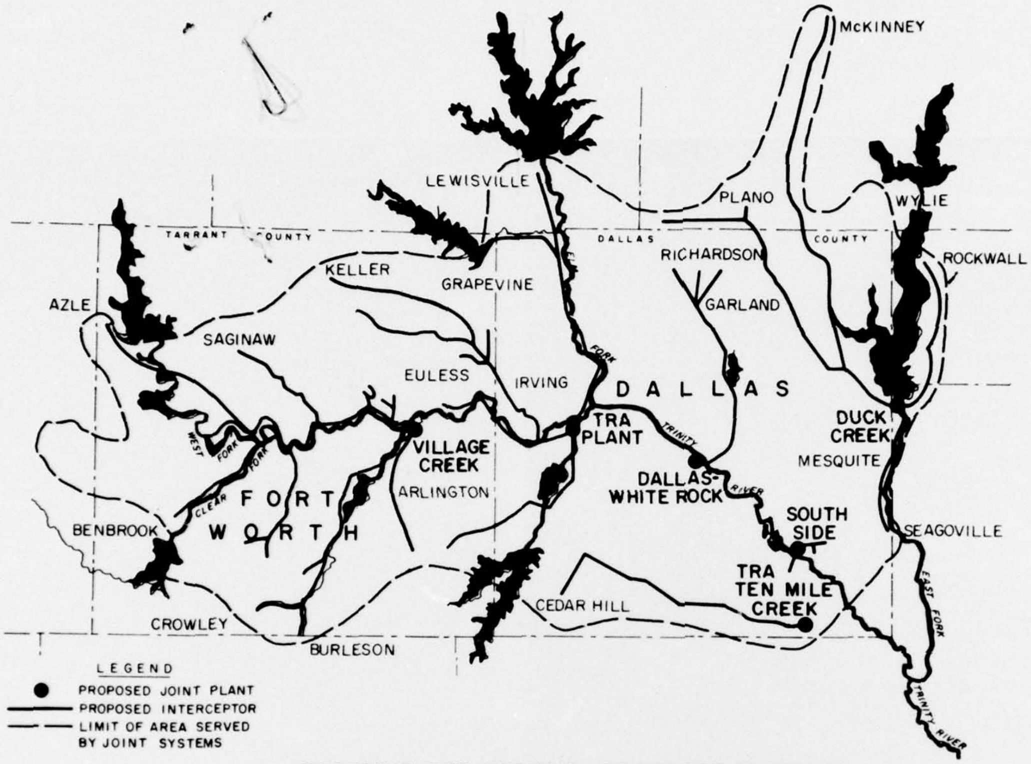
NCTCO
mentation
completed
rate report

The study indicates that by the year 2020 the metropolitan area of Dallas-Fort Worth will have 6.4 million residents. The combined urban and rural population will grow to over 7.8 million people.

They will consume approximately 1,509 million gallons of water per day. Sewage flow in 2020 will reach an estimated 1,130 million gallons per day.

separate plants, much as they do today, since joint plant construction would not be economically feasible.

Upgrading of the present sewage treatment facilities to increase the quality of the effluent would insure efficient pollution control.



RECOMMENDED REGIONAL SEWERAGE SYSTEMS

The report recommends phasing out 47 metropolitan area plants. The remaining six joint plants would be expanded to produce high quality effluent. By 1990, combined facilities would handle 92% of the sewage in the study area.

Residents of the North Central Region cannot expect the pollution problem to solve itself. Communities must take preventive action to retard the spread of pollution throughout their lakes, rivers and streams and into their water supplies. Although the study presents a comprehensive 50-year pollution and water quality control plan, its benefits would be realized immediately.

With the addition of possible state and federal money, construction costs assumed by the individual may decrease to less than the 20¢ per day per family.

The Comprehensive Sewerage Plan for the Upper Trinity River Basin helps communities accomplish two vital and important regional goals:

1. Consolidation of sewage treatment facilities will efficiently and economically improve the quality of water in North Central Texas.

2. The study provides a practical method of combating environmental pollution through advance planning for the next 50 years.

A workable plan for implementation of the Comprehensive Sewerage Plan needs extensive regional coordination and cooperation.

NCTCOG's suggestions for implementation and financing have been completed and are available in a separate report.

The lakes, rivers, and streams of North Central Texas are becoming polluted. They are *filling up with nutrients*. Algae and aquatic plant life are increasing. Game fish are dying.

Lakes which once furnished abundant water supplies and recreational facilities have developed into health hazards.

As long as the regulation of pollution sources remains uncoordinated, the balance of "safe" water supplying your community decreases.

Pollution of the Upper Trinity River Basin from 1) municipal sewage, 2) industrial wastewater, or 3) surface runoff from urban or rural sources, contaminate stream flows.

The region must devise a satisfactory method for disposal of sewage from Dallas-Fort Worth and some 300 other municipalities in the basin . . . the largest of the contributing factors in the pollution problem.

Only a consolidated effort initiated by local communities, assisted by regional and state planning bodies, can guard future regional development through advance environmental planning.

Non-profit Organization
U.S. Postage
P A I D
Arlington, Texas
Permit No. 90

North Central Texas Council of Governments
Post Office Box 5888
Arlington, Texas 76011